



A Photographic Atlas

# **Anatomy &** *for the* **Physiology** LABORATORY

*Kent M. Van De Graaff*  
*David A. Morton*  
*& John L. Crawley*  
**SEVENTH EDITION**



# **A Photographic Atlas for the Anatomy and Physiology Laboratory**

SEVENTH EDITION

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**To Kent, a teacher, mentor, colleague, and friend.**

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## Preface

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Human anatomy is the scientific discipline that investigates the structure of the body and human physiology is the scientific discipline that investigates how body structures function. These subjects may be taught independent of each other in separate courses, or they may be taught together in integrated anatomy and physiology courses. Regardless of whether or not anatomy is taught independently from physiology or if the two disciplines are integrated as a single course, it is necessary for a student to have a conceptualized visualization of body structure and a knowledge of its basic descriptive anatomical terminology in order to understand how the body functions.

A Photographic Atlas for the Anatomy and Physiology Laboratory is designed for all students taking separate or integrated courses in human anatomy and physiology. This atlas can accompany and will augment any human anatomy, human physiology, or combined human anatomy and physiology textbook. It is designed to be of particular value to students in a laboratory situation and could either accompany a laboratory manual or in certain courses, serve as the laboratory manual.

Anatomy and physiology are visually oriented sciences. Great care has gone into the preparation of this photographic atlas to provide students with a complete set of photographs for each of the human body systems. Human cadavers have been carefully dissected and photographs taken that clearly depict each of the principal organs from each of the body systems. Cat dissection, fetal pig dissection, and rat dissection are also included for those students who have the opportunity to do similar dissection as part of their laboratory requirement. In addition, photographs of a sheep heart dissection are also included.

A visual balance is achieved in this atlas between the various levels available to observe the structure of the body. Microscopic anatomy is presented by photomicrographs at the light microscope level and electron micrography from scanning and transmission electron microscopy. Carefully selected photographs are used throughout the atlas to provide a balanced perspective of the gross anatomy. At the request of several professors who used previous editions of the atlas, the muscular and circulatory sections have been expanded and improved with new photographs, illustrations, and tables. The section on articulations has been improved with the inclusion of photographs of joint dissections. Selected X-rays, CT scans, and MR images depict structures from living persons and thus provide an applied dimension to the atlas. Great care has been taken to construct completely labeled, informative figures that are depicted clearly and accurately. The terminology used in this atlas are those that are approved and recommended by the Basle Nomina Anatomica (BNA).

## Preface to seventh Edition

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New editions are desirable for authors because it presents an opportunity to improve upon a successful product. Revision, such as is presented in the seventh edition of A Photographic Atlas for the Human Anatomy and Physiology Laboratory, requires an inordinate amount of planning, organization, and work. As authors we have the opportunity and obligation to listen to the critiques and suggestions from students and faculty who have used this atlas. This constructive input has resulted in a product that is greatly improved. We appreciate those who have taken the time to provide suggestions and indicate corrections.

One of the objectives in preparing this atlas was to create an inviting pedagogy. The page layout has been improved by careful selection of photographs, and when necessary, provide accompanying line art which has been completely updated and several new illustrations added. Each image in this atlas has been carefully evaluated for its quality, effectiveness, and accuracy. Black backgrounds for the depicted specimens enhance the clarity of the images. Many photographs have been improved or replaced by better photographs and the leader lines are better sized to aid in the identification of structures. Major changes were made in chapters devoted to the circulatory system and specimen dissections.

## Acknowledgments

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Many individuals contributed to the preparation of the sixth edition of A Photographic Atlas for the Human Anatomy and Physiology Laboratory. We are especially appreciative of Chris Steadman, Aaron Bera and Steven Taylor who helped conduct the tedious and meticulous dissections of the cadavers. They were enjoyable to work with and were conscientious in meeting the dissection schedule. We are also grateful for Dr. Robert Seegmiller of Brigham Young University for his help in acquiring specimens.

It is gratifying to have professors and health-care professionals interested in the success of A Photographic Atlas for the Human Anatomy and Physiology Laboratory. There are several that were helpful in the development of this atlas. They share our enthusiasm of its value for students of anatomy and physiology. We are especially appreciative of Kyle M. Van De Graaff, M.D. and William B. Winborn, Ph.D. at the University of Texas Health Science Center at San Antonio for their efforts and generosity in providing the choice photomicrographs used in this atlas. The radiographs, CT scans, and MR images were made possible through the generosity of Gary M. Watts, M.D. and the Department of Radiology at Utah Valley Regional Medical Center. Kerry Peterson for the use of his dissections. We thank Jake Christiansen, James Barrett and Austen Slade for their specimen dissections. Others who aided in specimen dissections were Nathan A. Jacobson, D.O., R. Richard Rasmussen, M.D., and Sandra E. Sephton, Ph.D. We appreciate the talents of Imagineering who rendered the line art throughout the atlas. Many users and reviewers of the previous editions of this atlas provided suggestions for its improvement. We are especially appreciative of Michael J. Shively, D.V.M. for his numerous comments and helpful suggestions. Special thanks to Dr. Michele Robichaux of Nicholls State University, Penny Dobbins of the University of Connecticut, Kerrie L. Hoar of the University of Wisconsin at La Crosse, and Susan Spencer of Mt. Hood Community College for their help in reviewing this atlas. We appreciate Focus Design for their help with laying out the atlas. We are indebted to Douglas Morton and the personnel at Morton Publishing Company for the opportunity, encouragement, and support to complete this project.

# Chapter 1

## Body Organization

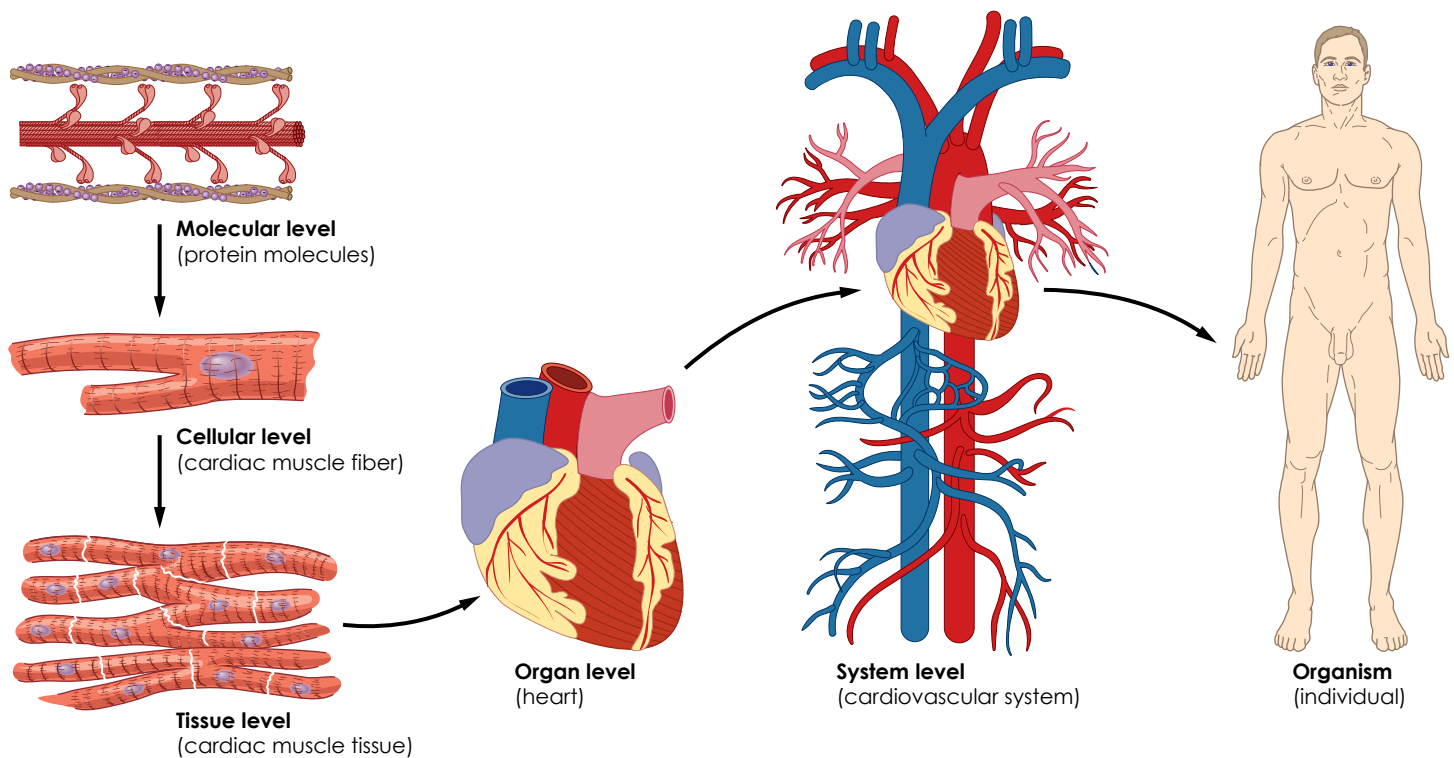
**Anatomy** is the study of body structures. An example of an anatomical study is learning about the structure of the heart—the chambers, valves, and vessels that serve the heart muscle. **Physiology** is the study of body function. An example of a physiological study is learning what causes the heart muscles to contract—the sequence of blood flow through the heart and what causes blood pressure. The anatomy (structure) and the physiology (function) of any part of the body are always related, or in other words, structure determines function.

Most of the physiological processes within the body act to maintain **homeostasis**. Simply defined, homeostasis is maintaining nearly consistent internal conditions within the body despite changing conditions in the external environment. For example, one area of your brain acts as a thermostat to keep your body temperature near 37°C (98.6°F). Being too warm causes you to sweat and cool the body, while being cold causes you to shiver and

warm the body. Maintaining overall body homeostasis is achieved through many interacting physiological processes involving all levels of body organization, and is absolutely necessary for survival.

Structural and functional levels of organization exist in the body, and each of its parts contributes to the total organism. In the study of human anatomy and physiology, the following levels of body organization are generally recognized—the molecular level, the cellular level, the tissue level, the organ level, the system level, and the organismic level (fig. 1.1).

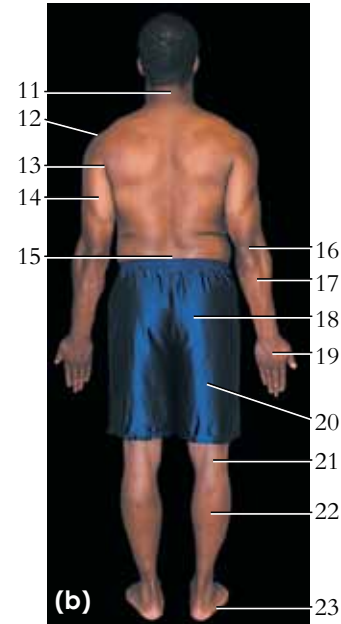
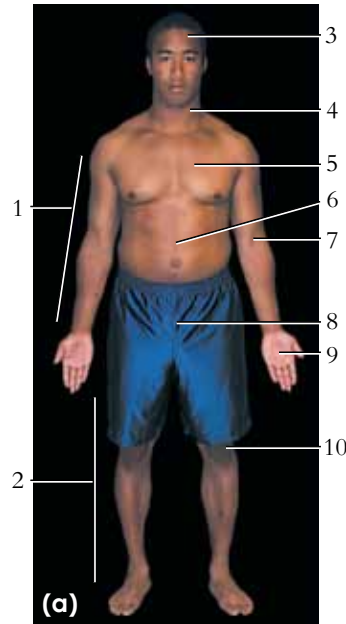
**Cells** are microscopic and are the smallest living part of all organisms. **Tissues** are of groups of similar cells that perform specific functions. An **organ** is an aggregate of two or more tissues integrated to perform a particular function. The **systems** of the body consist of various body organs that have similar or related functions. All the systems of the body are interrelated and function together constituting the **organism**.



**Figure 1.1** The levels of structural organization and complexity within the body.



**Figure 1.2** The anatomical position provides a basis of reference for describing the relationship of one body part to another. In the anatomical position, the person is standing, the feet are parallel, the eyes are directed forward, and the arms are to the sides with the palms turned forward and the fingers are pointed straight down.



**Figure 1.3** The major body parts and regions in humans (bipedal vertebrate). (a) An anterior view and (b) a posterior view.

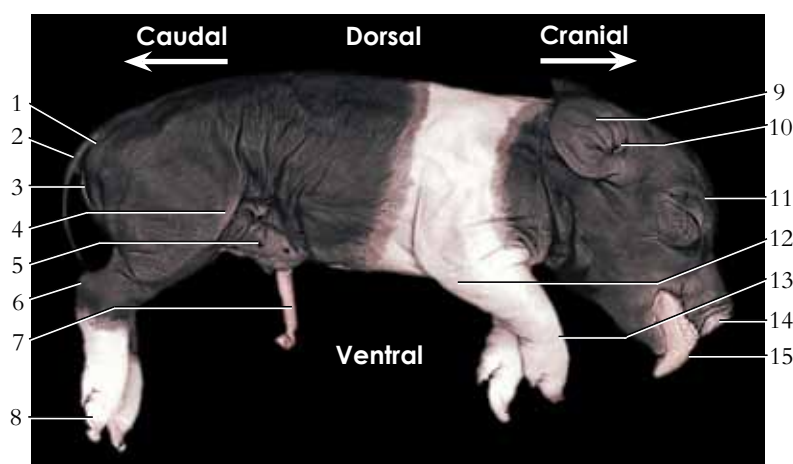
- |                          |                               |                              |
|--------------------------|-------------------------------|------------------------------|
| 1. Upper extremity       | 9. Palmar region (palm)       | 17. Antebrachium (forearm)   |
| 2. Lower extremity       | 10. Patellar region (patella) | 18. Gluteal region (buttock) |
| 3. Head                  | 11. Cervical region           | 19. Dorsum of hand           |
| 4. Neck, anterior aspect | 12. Shoulder                  | 20. Thigh                    |
| 5. Thorax (chest)        | 13. Axilla (armpit)           | 21. Popliteal fossa          |
| 6. Abdomen               | 14. Brachium (upper arm)      | 22. Calf                     |
| 7. Cubital fossa         | 15. Lumbar region             | 23. Plantar surface (sole)   |
| 8. Pubic region          | 16. Elbow                     |                              |

**Table 1.1** Directional terminology for describing human body structures.

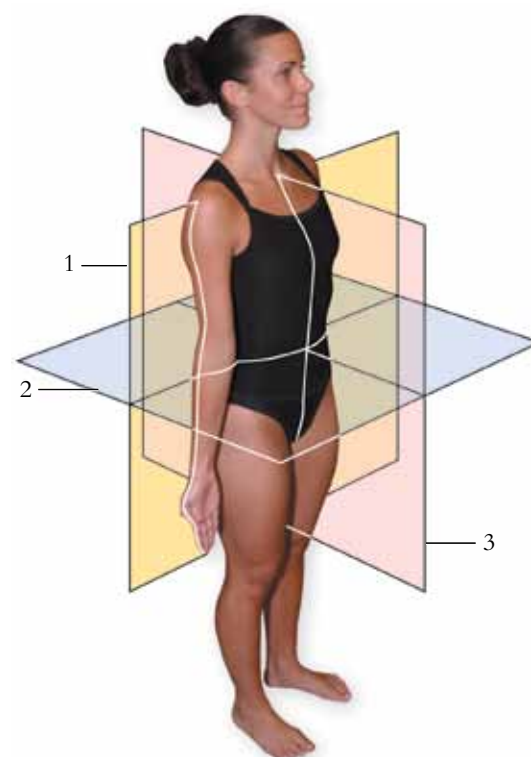
| Term                                   | Definition   | Example   |
|--|--|---|
| <b>Superior</b><br>(cephalic, cranial) | Toward the top of the head                                   | The neck is superior to the thorax.                                       |
| <b>Inferior</b><br>(caudal)            | Away from the top of the head                                | The pubic region is inferior to the abdomen.                              |
| <b>Anterior</b><br>(ventral)           | Toward the front of the body                                 | The eyes, nose, and mouth are on the anterior side of the body.           |
| <b>Posterior</b><br>(dorsal)           | Toward the back of the body                                  | The spinal cord extends down the posterior side of the body.              |
| <b>Lateral</b>                         | Toward the side of the body                                  | The arms are on the lateral sides of the body.                            |
| <b>Medial</b>                          | Toward the median plane of the body                          | The heart is medial to the lungs.   |
| <b>Superficial</b><br>(external)       | Toward the surface of the body                               | The skin is superficial to the muscles.                                   |
| <b>Deep</b><br>(internal)              | Away from the surface of the body                            | The heart is positioned deep within the thoracic cavity.                  |
| <b>Parietal</b>                        | Reference to the body wall of the trunk (thorax and abdomen) | The parietal peritoneum is the membrane lining the abdominal cavity.      |
| <b>Visceral</b>                        | Reference to internal organs of trunk                        | The stomach is covered by a thin membrane called the visceral peritoneum. |

**Table 1.2** Directional terminology for describing quadrupedal body structures.

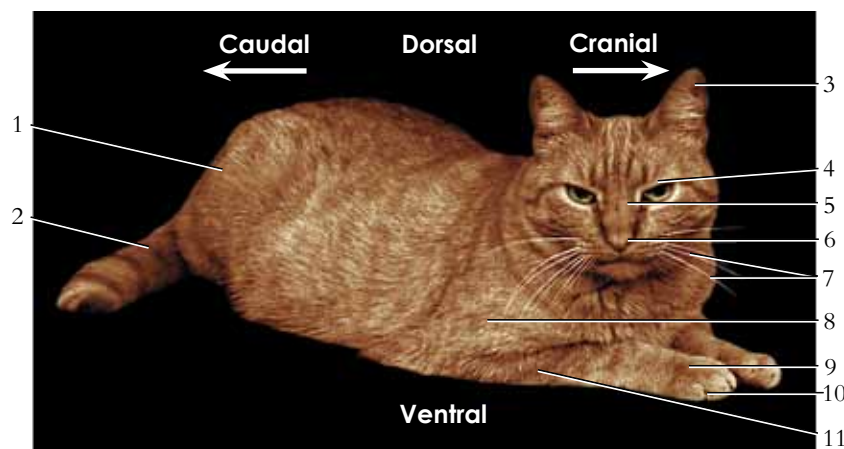
| Term           | Definition   | Example   |
|----------------|--|---|
| <b>Cranial</b> | Toward the head  | The neck is cranial to the thorax.                |
| <b>Caudal</b>  | Toward the Tail  | The pubic region is caudal to the abdomen.        |
| <b>Dorsal</b>  | The back (equivalent to posterior when referring to the human body)      | The shoulder blade is dorsal to the rib cage.     |
| <b>Ventral</b> | The belly side (equivalent to anterior when referring to the human body) | The navel is on the ventral surface of the trunk. |

**Figure 1.4** The directional terminology and superficial structures in a fetal pig (quadrupedal vertebrate).

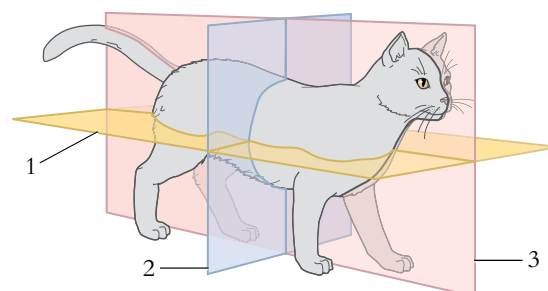
- |                   |   |                     |
|-------------------|---|---------------------|
| 1. Anus           | 8. Hoof                                 | 13. Wrist           |
| 2. Tail           | 9. Auricle (pinna)                      | 14. Naris (nostril) |
| 3. Scrotum        | 10. External auditory canal             | 15. Tongue          |
| 4. Knee           | 11. Superior palpebra (superior eyelid) |                     |
| 5. Teat           | 12. Elbow                               |                     |
| 6. Ankle          |   |                     |
| 7. Umbilical cord |   |                     |

**Figure 1.5** The planes of reference in a human (bipedal vertebrate).

1. Coronal plane (frontal plane)
2. Transverse plane (cross-sectional plane)
3. Sagittal plane

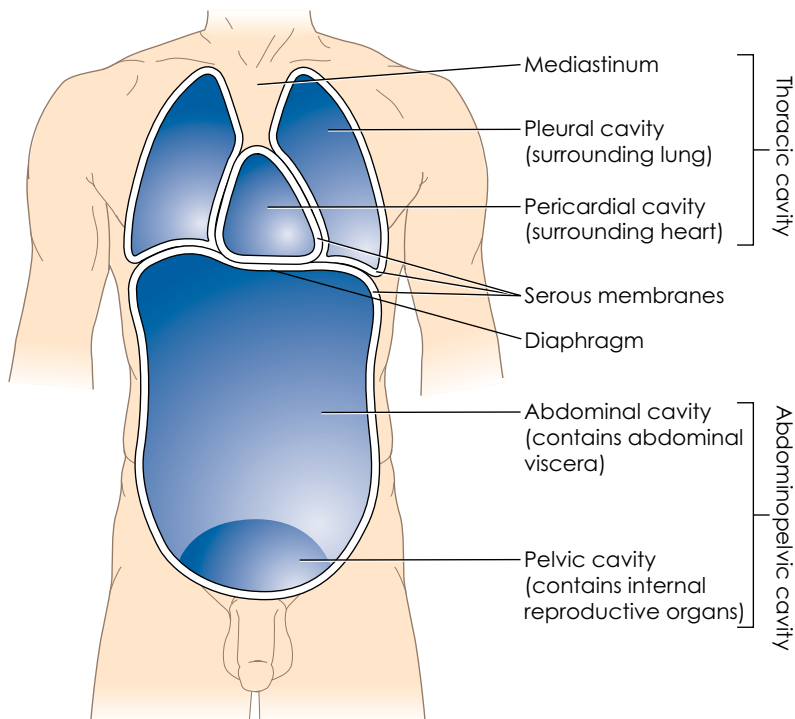
**Figure 1.6** The directional terminology and superficial structures in a cat (quadrupedal vertebrate).

- |  |                       |                  |
|--|-----------------------|------------------|
| 1. Thigh                               | 5. Bridge of nose     | 10. Claw         |
| 2. Tail                                | 6. Naris (nostril)    | 11. Antebrachium |
| 3. Auricle (pinna)                     | 7. Vibrissae          |                  |
| 4. Superior palpebra (superior eyelid) | 8. Brachium           |                  |
|  | 9. Manus (front foot) |                  |

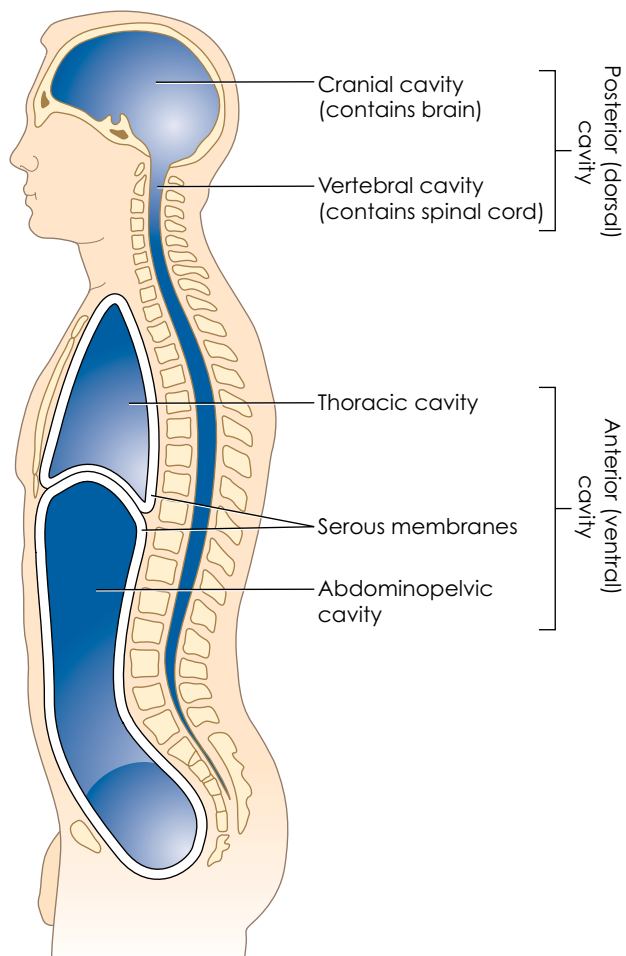
**Figure 1.7** The planes of reference in a cat (quadrupedal vertebrate).

1. Coronal plane (frontal plane)
2. Transverse plane (cross-sectional plane)
3. Sagittal plane





**Figure 1.8** An anterior view of the body cavities of the trunk.

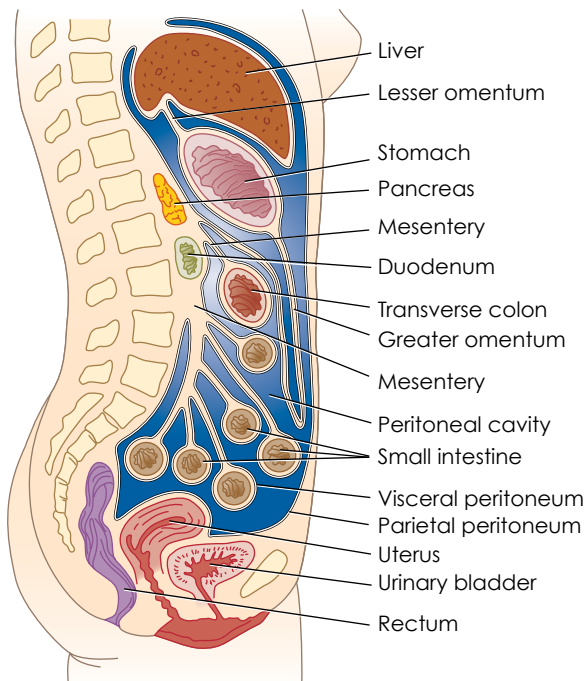


**Figure 1.10** A midsagittal view of the body cavities.



**Figure 1.9** An MR image of the trunk showing the body cavities and their contents.

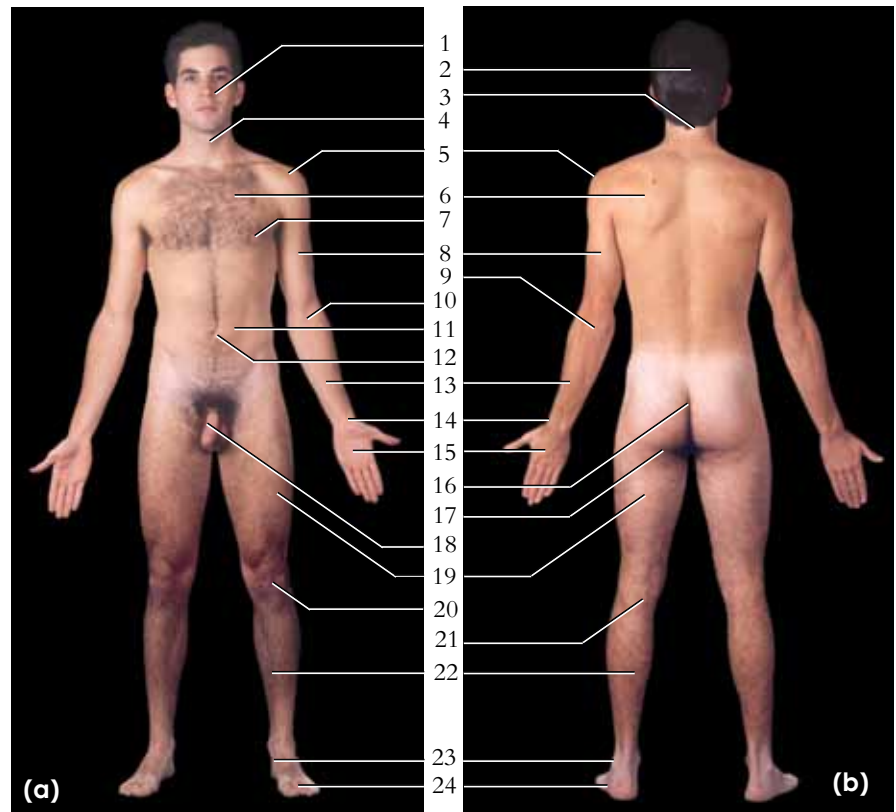
- |                          |                             |
|--------------------------|-----------------------------|
| 1. Thoracic cavity       | 5. Image of rib             |
| 2. Abdominopelvic cavity | 6. Image of lumbar vertebra |
| 3. Image of heart        | 7. Image of Ilium           |
| 4. Image of diaphragm    |                             |



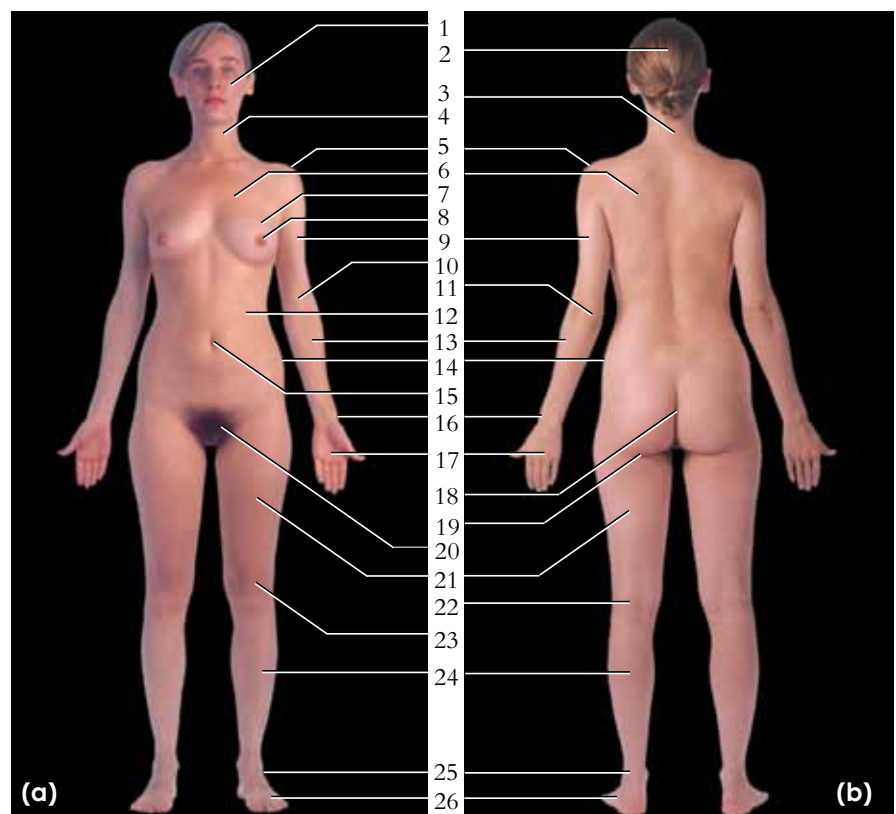
**Figure 1.11** A midsagittal view of the organs of the abdominopelvic cavity and their supporting membranes.

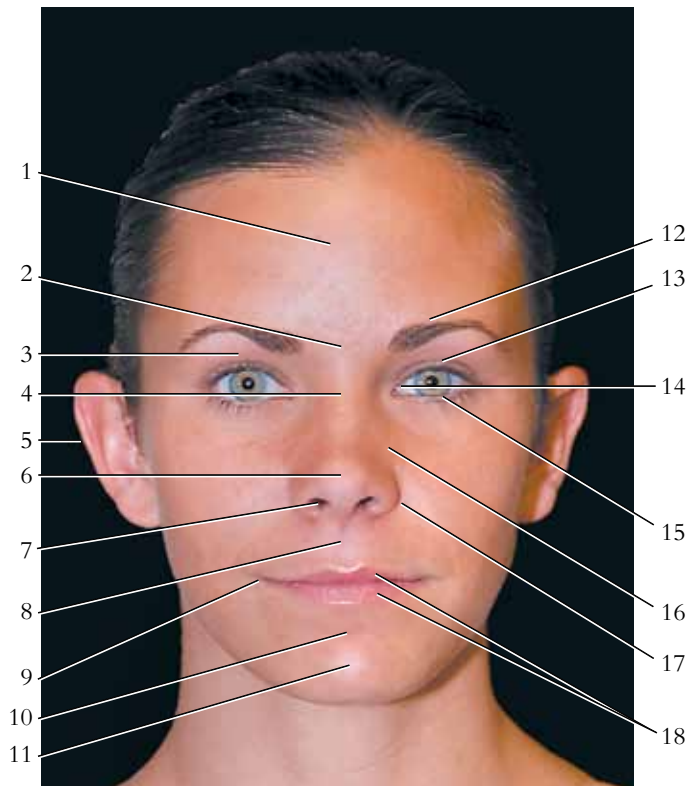
**Figure 1.12** The human male.

- (a) Anterior view  
(b) Posterior view
1. Facial region
  2. Cranial region
  3. Posterior neck
  4. Anterior neck
  5. Shoulder
  6. Thorax
  7. Nipple
  8. Brachium
  9. Elbow
  10. Cubital fossa
  11. Abdomen
  12. Umbilicus (navel)
  13. Antebrachium
  14. Wrist
  15. Hand
  16. Natal (gluteal) cleft
  17. Fold of buttock (gluteal fold)
  18. External genitalia
  19. Thigh
  20. Patella
  21. Popliteal fossa
  22. Leg
  23. Ankle
  24. Foot

**Figure 1.13** The human female.

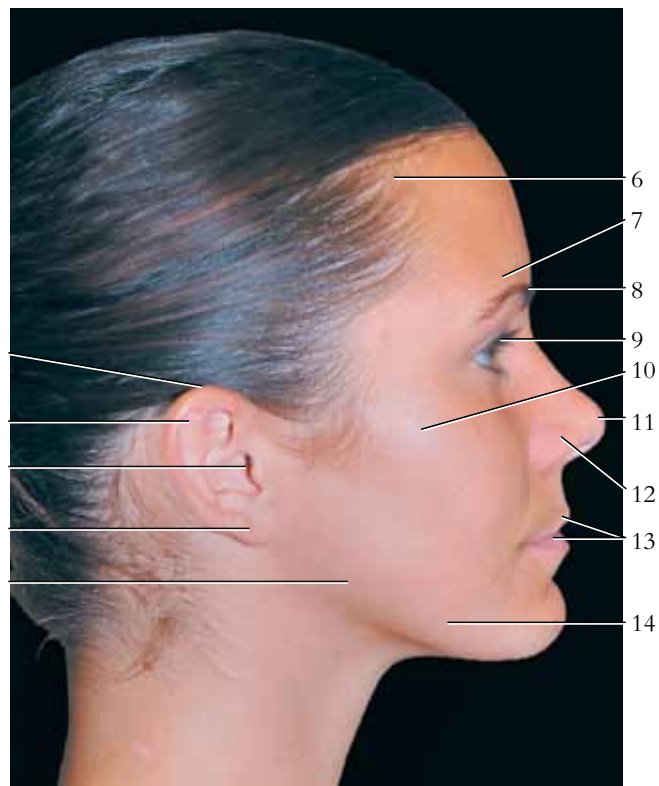
- (a) Anterior view  
(b) Posterior view
1. Facial region
  2. Cranial region
  3. Posterior neck
  4. Anterior neck
  5. Shoulder
  6. Thorax
  7. Breast
  8. Nipple
  9. Brachium
  10. Cubital fossa
  11. Elbow
  12. Abdomen
  13. Antebrachium
  14. Iliac crest
  15. Umbilicus (navel)
  16. Wrist
  17. Hand
  18. Natal (gluteal) cleft
  19. Fold of buttock (gluteal fold)
  20. Mons pubis
  21. Thigh
  22. Popliteal fossa
  23. Patella
  24. Leg
  25. Ankle
  26. Foot





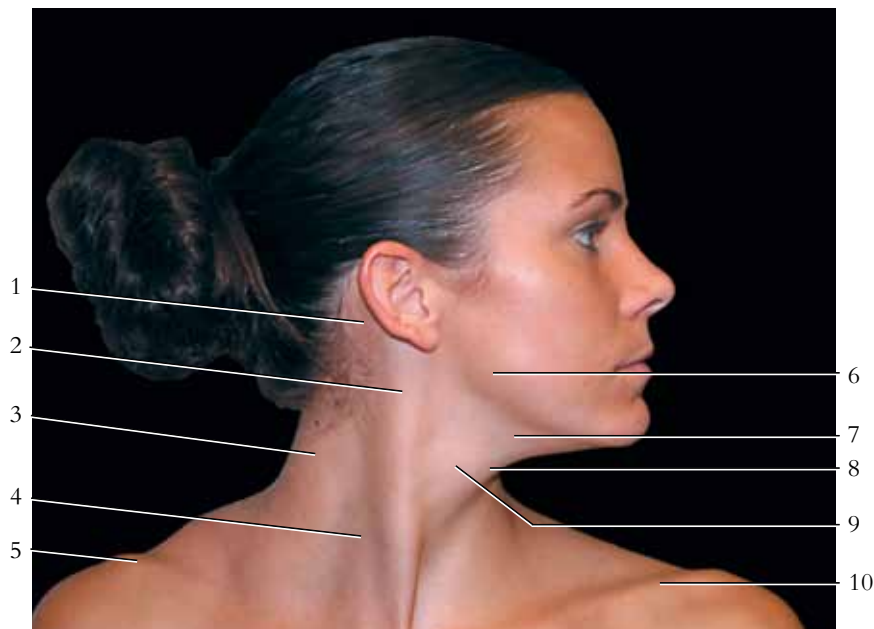
**Figure 1.14** An anterior view of the facial region.

- |                              |                               |
|------------------------------|-------------------------------|
| 1. Forehead                  | 10. Mentolabial sulcus        |
| 2. Root of nose (glabella)   | 11. Chin (mentalis)           |
| 3. Superior palpebral sulcus | 12. Eyebrow                   |
| 4. Bridge of nose            | 13. Eyelashes of upper eyelid |
| 5. Auricle (pinna)           | 14. Lacrimal caruncle         |
| 6. Apex of nose              | 15. Eyelashes of lower eyelid |
| 7. Nostril                   | 16. Nasofacial angle          |
| 8. Philtrum                  | 17. Alar nasal sulcus         |
| 9. Corner of mouth           | 18. Lips                      |



**Figure 1.15** A lateral view of the facial region.

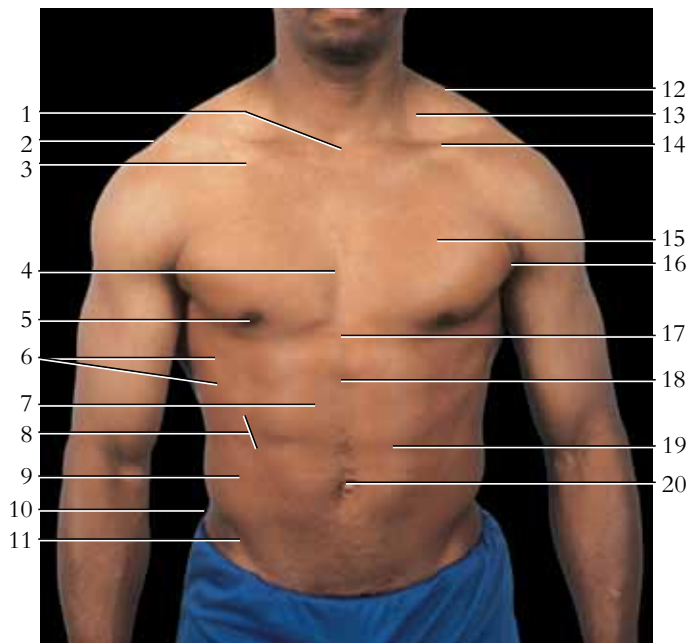
- |                            |                      |
|----------------------------|----------------------|
| 1. Helix of auricle        | 8. Eyebrow           |
| 2. Antihelix               | 9. Eyelashes         |
| 3. External auditory canal | 10. Zygomatic arch   |
| 4. Earlobe                 | 11. Apex of nose     |
| 5. Angle of mandible       | 12. Ala nasi         |
| 6. Hair line               | 13. Lips             |
| 7. Superciliary ridge      | 14. Body of mandible |



**Figure 1.16** An anterolateral view of the neck. (m. = muscle)

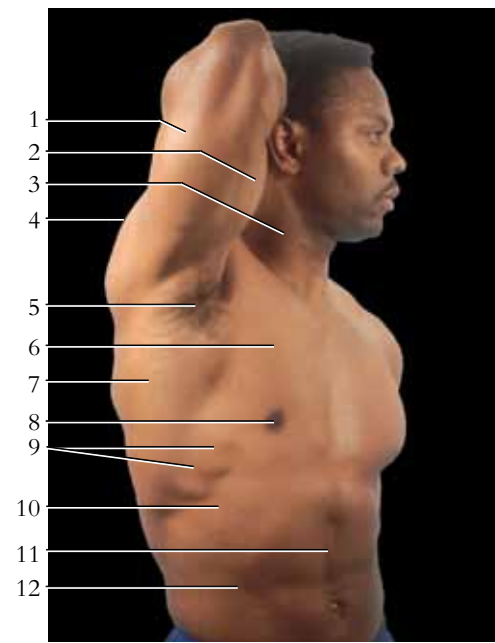
- |                                |
|--------------------------------|
| 1. Mastoid process             |
| 2. Sternocleidomastoid m.      |
| 3. Trapezius m.                |
| 4. Posterior triangle of neck  |
| 5. Acromion of scapula         |
| 6. Angle of mandible           |
| 7. Hyoid bone                  |
| 8. Thyroid cartilage of larynx |
| 9. Anterior triangle of neck   |
| 10. Clavicle                   |





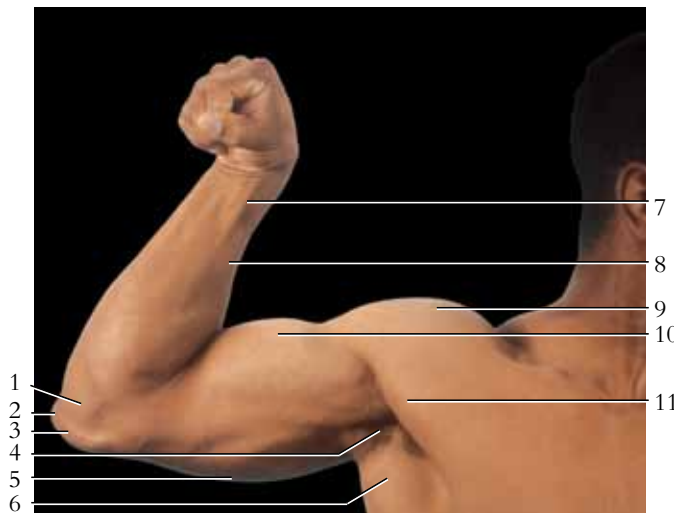
**Figure 1.17** An anterior view of the thorax and abdomen.

- |                                  |                            |
|----------------------------------|----------------------------|
| 1. Jugular notch                 | 11. Inguinal ligament      |
| 2. Acromion of scapula           | 12. Trapezius m.           |
| 3. Clavipectoral triangle        | 13. Supraclavicular fossa  |
| 4. Sternum                       | 14. Clavicle               |
| 5. Nipple                        | 15. Pectoralis major m.    |
| 6. Serratus anterior m.          | 16. Anterior axillary fold |
| 7. Rectus abdominis m.           | 17. Xiphoid process        |
| 8. Linea semilunaris             | 18. Linea alba             |
| 9. External abdominal oblique m. | 19. Tendinous inscription  |
| 10. Iliac crest                  | 20. Umbilicus              |



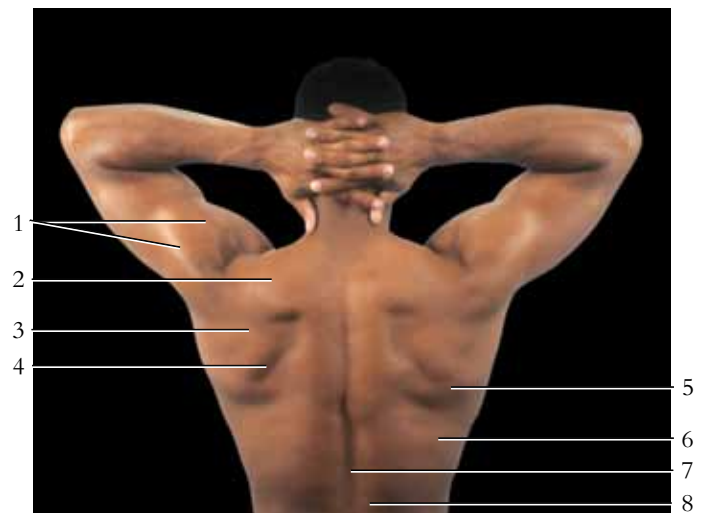
**Figure 1.18** An anterolateral view of the thorax, abdomen, and axilla.

- |                           |                                   |
|---------------------------|-----------------------------------|
| 1. Triceps brachii m.     | 8. Nipple                         |
| 2. Biceps brachii m.      | 9. Serratus anterior m.           |
| 3. Sternocleidomastoid m. | 10. Intercostal m.                |
| 4. Deltoid m.             | 11. Linea alba                    |
| 5. Axilla                 | 12. External abdominal oblique m. |
| 6. Pectoralis major m.    |                                   |
| 7. Latissimus dorsi m.    |                                   |



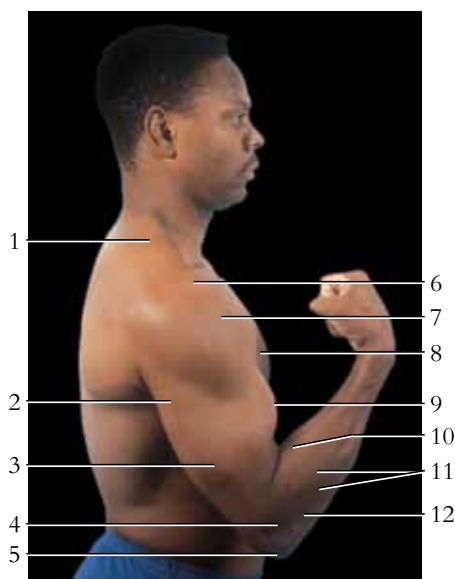
**Figure 1.19** The right shoulder, axilla, and upper extremity.

- |  |  |
|--|--|
| 1. Medial epicondyle of humerus                  | 7. Tendon of flexor carpi radialis longus m.     |
| 2. Olecranon of ulna                             | 8. Brachioradialis m.                            |
| 3. Ulnar Sulcus                                  | 9. Deltoid m.                                    |
| 4. Axilla  | 10. Biceps brachii m.                            |
| 5. Triceps brachii m.                            | 11. Pectoralis major m. (anterior axillary fold) |
| 6. Latissimus dorsi m. (posterior axillary fold) |  |



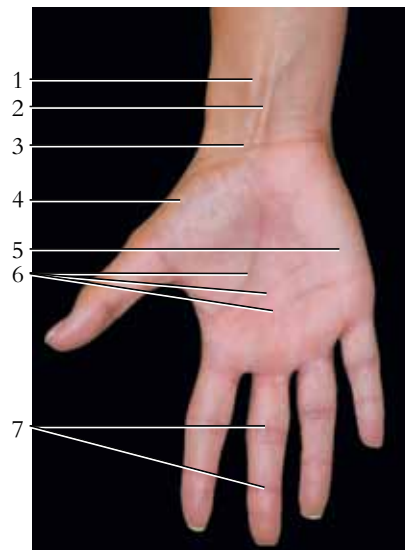
**Figure 1.20** A posterior view of the thorax.

- |  |
|--|
| 1. Deltoid m.                          |
| 2. Trapezius m.                        |
| 3. Infraspinatus m.                    |
| 4. Triangle of auscultation            |
| 5. Inferior angle of scapula           |
| 6. Latissimus dorsi m.                 |
| 7. Median furrow over vertebral column |
| 8. Erector spinae m.                   |



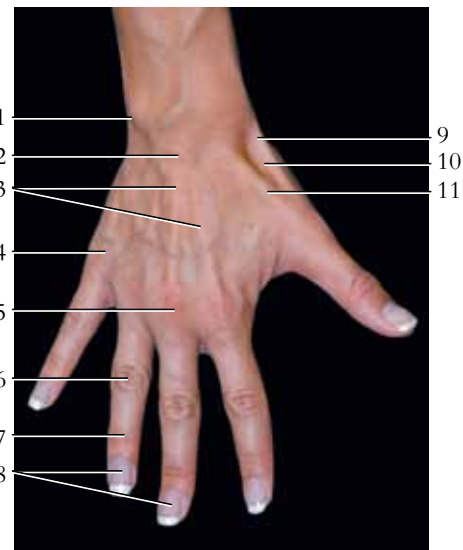
**Figure 1.21** A lateral view of the right shoulder and upper extremity. (m. = muscle, mm. = muscles)

1. Trapezius m.
2. Long head of triceps brachii m.
3. Lateral head of triceps brachii m.
4. Lateral epicondyle of humerus
5. Olecranon of ulna
6. Acromion of scapula
7. Deltoid m.
8. Pectoralis major m.
9. Biceps brachii m.
10. Brachioradialis m.
11. Extensor carpi radialis longus and brevis mm.
12. Extensor digitorum m.



**Figure 1.22** An anterior view of the right hand.

1. Tendon of flexor carpi radialis m.
2. Tendon of palmaris longus m.
3. Flexion crease on wrist
4. Thenar eminence
5. Hypothenar eminence
6. Flexion creases on palm of hand
7. Flexion creases on third digit

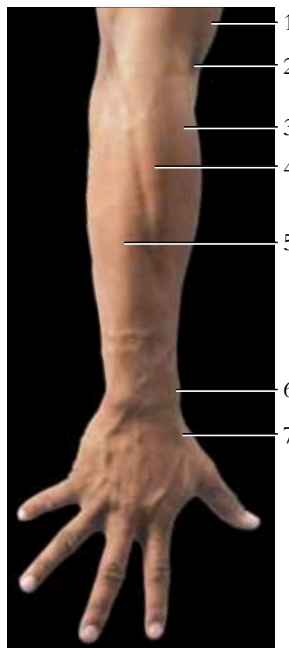


**Figure 1.23** A posterior view of the right hand.

1. Styloid process of ulna
2. Position of extensor retinaculum
3. Tendons of extensor digitorum m.
4. Tendon of extensor digiti minimi m.
5. Metacarpophalangeal joint
6. Proximal interphalangeal joint
7. Distal interphalangeal joint
8. Nails
9. Tendon of extensor pollicis brevis m.
10. Anatomical snuffbox
11. Tendon of extensor pollicis longus m.

**Figure 1.24** An anterior view of the right upper extremity.

1. Cephalic vein
2. Biceps brachii m.
3. Cubital fossa
4. Brachioradialis m.
5. Cephalic vein
6. Site for palpation of radial artery
7. Tendon of flexor carpi radialis m.
8. Tendon of palmaris longus m.
9. Thenar eminence
10. Metacarpophalangeal joint of thumb
11. Site of palpation of brachial artery
12. Basilic vein
13. Median cubital vein
14. Ulnar vein
15. Median antebrachial vein
16. Tendon of superficial digital flexor m.
17. Styloid process of ulna
18. Hypothenar eminence



**Figure 1.25** A posterior view of the right upper extremity.

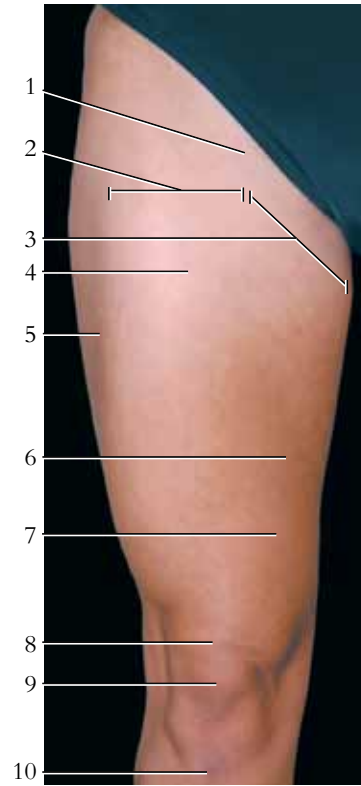
1. Biceps brachii m.
2. Cubital fossa
3. Brachioradialis m.
4. Extensor carpi radialis longus m.
5. Extensor carpi ulnaris m.
6. Styloid process of radius
7. Tendon of extensor pollicis longus m.





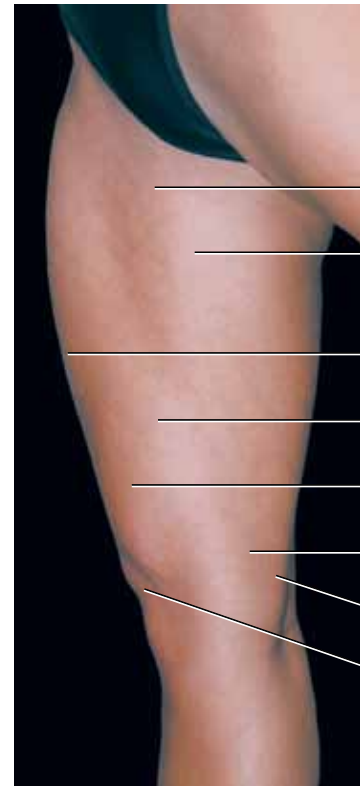
**Figure 1.26** An anterior view of the right thigh.

1. Site of femoral triangle
2. Quadriceps femoris group of muscles
3. Adductor group of muscles
4. Rectus femoris m.
5. Vastus lateralis m.
6. Sartorius m.
7. Vastus medialis m.
8. Tendon of quadriceps femoris m.
9. Patella
10. Patellar ligament



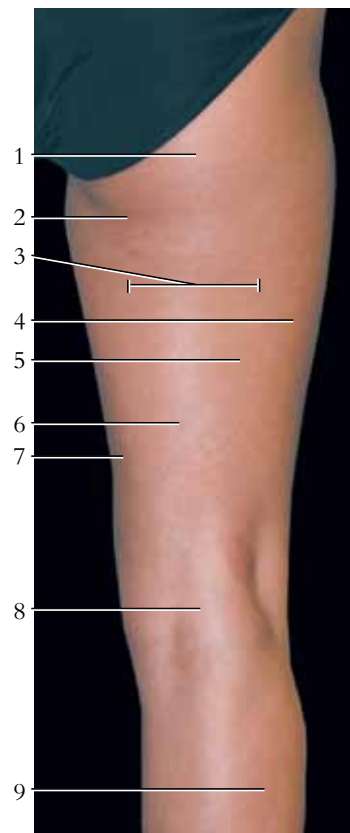
**Figure 1.27** A medial view of the right thigh.

1. Adductor magnus m.
2. Gracilis m.
3. Rectus femoris m.
4. Sartorius m.
5. Vastus medialis m.
6. Semimembranosus m.
7. Semitendinosus m.
8. Patella



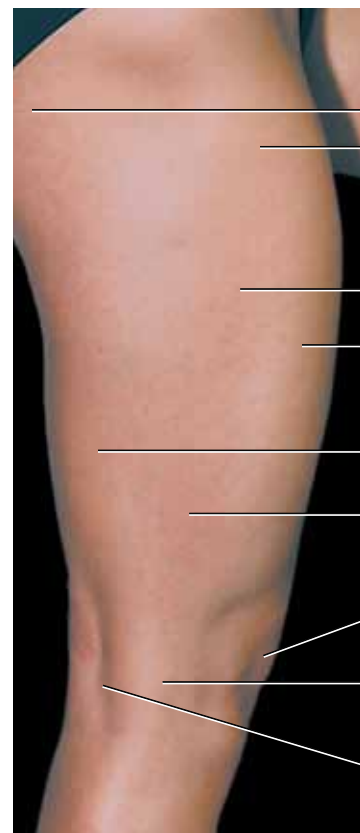
**Figure 1.28** A posterior view of the right thigh.

1. Gluteus maximus m.
2. Fold of buttock (gluteal fold)
3. Hamstring group of muscles
4. Vastus lateralis m.
5. Long head of biceps femoris m.
6. Semitendinosus m.
7. Gracilis m.
8. Popliteal fossa
9. Lateral head of gastrocnemius m.



**Figure 1.29** A lateral view of the right thigh.

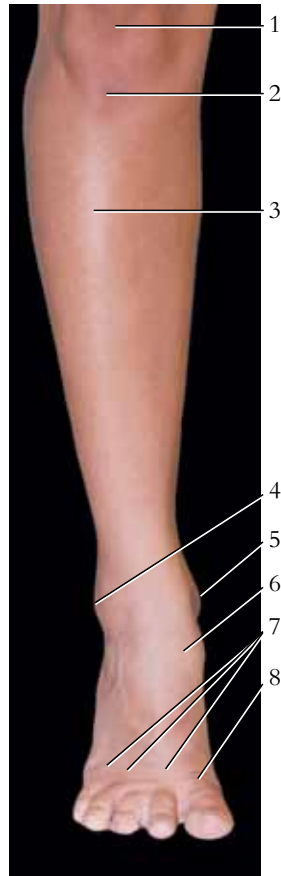
1. Gluteus maximus m.
2. Tensor fasciae latae m.
3. Vastus lateralis m.
4. Rectus femoris m.
5. Biceps femoris m.
6. Iliotibial tract
7. Patella
8. Lateral epicondyle of femur
9. Popliteal fossa





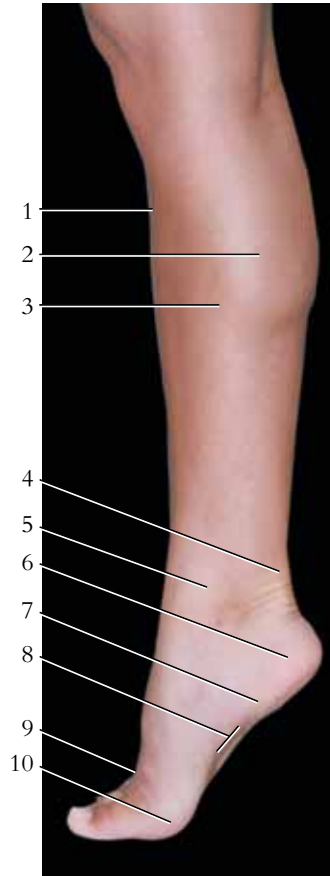
**Figure 1.30** An anterior view of the right leg and foot.

1. Patella
2. Patellar ligament
3. Tibialis anterior m.
4. Lateral malleolus of fibula
5. Medial malleolus of tibia
6. Site for palpation of dorsal pedis artery
7. Tendons of extensor digitorum longus m.
8. Tendon of extensor hallucis longus m.



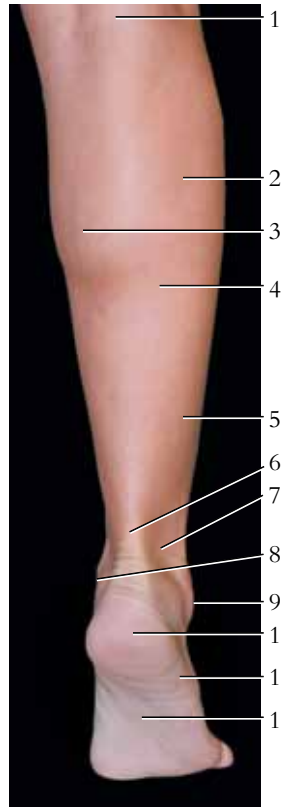
**Figure 1.31** A medial view of the right leg and foot.

1. Tibia
2. Medial head of gastrocnemius m.
3. Soleus m.
4. Tendo calcaneus
5. Medial malleolus of tibia
6. Calcaneus
7. Abductor hallucis m.
8. Longitudinal arch
9. Tendon of extensor hallucis longus m.
10. Head of first metatarsal bone



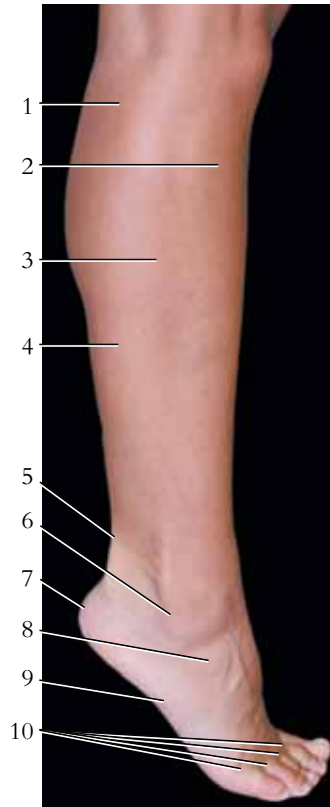
**Figure 1.32** A posterior view of the right leg and foot.

1. Popliteal fossa
2. Lateral head of gastrocnemius m.
3. Medial head of gastrocnemius m.
4. Soleus m.
5. Peroneus longus m.
6. Tendo calcaneus
7. Peroneus brevis m.
8. Medial malleolus of tibia
9. Lateral malleolus of fibula
10. Calcaneus
11. Abductor digiti minimi m.
12. Plantar surface of foot



**Figure 1.33** A lateral view of the right leg and foot.

1. Lateral head of gastrocnemius m.
2. Tibialis anterior m.
3. Peroneus longus m.
4. Soleus m.
5. Tendo calcaneus
6. Lateral malleolus of fibula
7. Calcaneus
8. Extensor digitorum brevis m.
9. Lateral surface of foot
10. Tendons of extensor digitorum longus m.



# Chapter 2

## Cells

**Cells** are the basic structural and functional units of organization within the body. Although diverse, human cells have structural similarities including a **nucleus** containing a nucleolus, various **organelles** suspended in **cytoplasm**, and an enclosing cell (plasma) **membrane** (fig. 2.1).

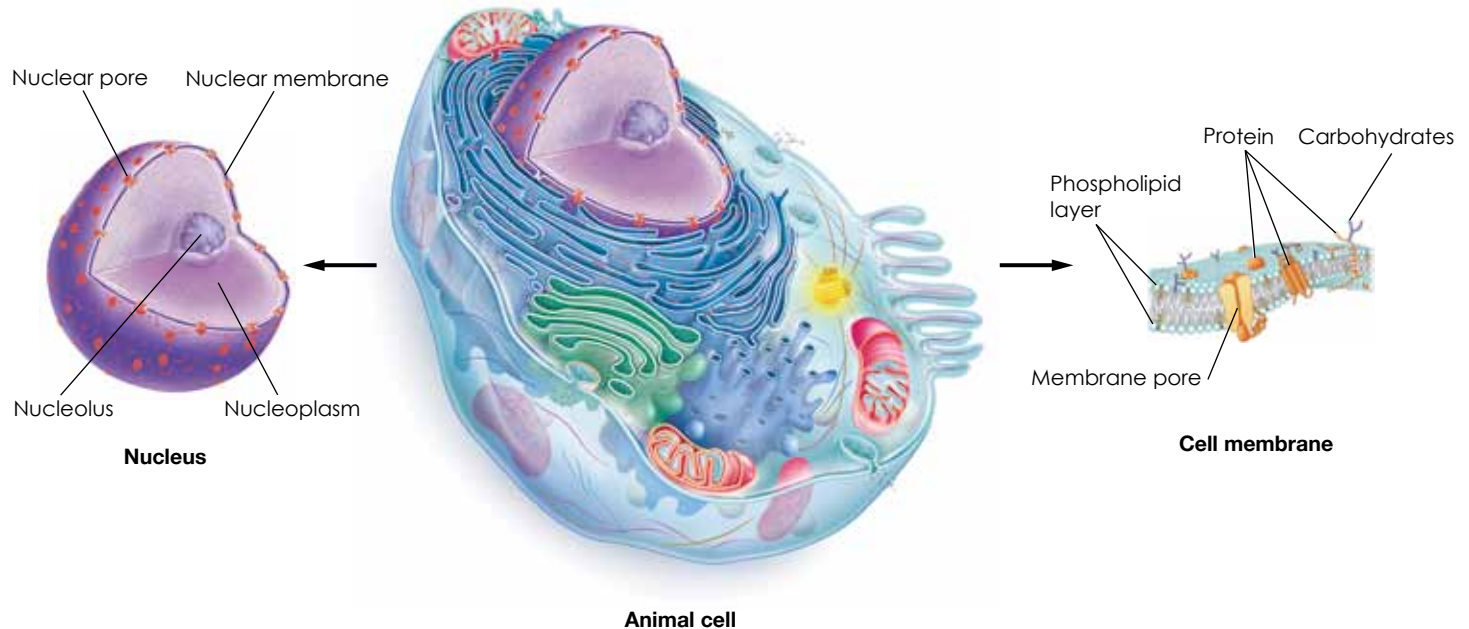
The **nucleus** is the large spheroid body within a cell that contains the **nucleoplasm**, one or more **nucleoli** and **chromatin**—the genetic material of the cell. The nucleus is enclosed by a double membrane called the **nuclear membrane**, or **nuclear envelope**. The **nucleolus** is a dense, nonmembranous body composed of protein and RNA molecules. The chromatin consists of protein and DNA molecules. Prior to cellular division, the chromatin shortens and coils into rod-shaped **chromosomes**. Chromosomes consist of DNA and proteins called **histones**.

The **cytoplasm** of a cell is the medium of support between the nuclear membrane and the cell membrane. **Organelles** are minute structures within the cytoplasm of a cell that are concerned with specific functions. The cellular functions carried out by the organelles are referred to as **cellular metabolism**. The principal organelles and their functions are

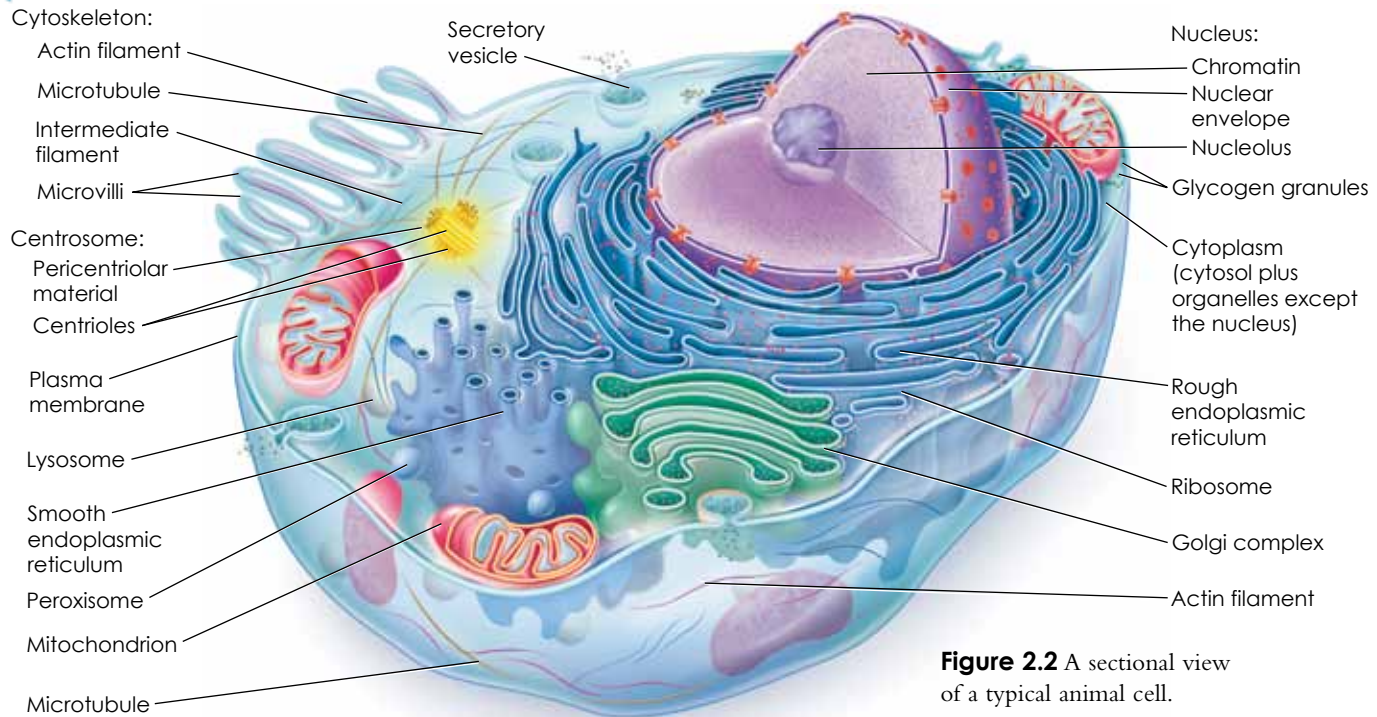
listed in Table 2.1. In order for cells to remain alive, metabolize, and maintain homeostasis, certain requirements must be met. These include having access to nutrients and oxygen, being able to eliminate wastes, and being maintained in a constant, protective environment.

The **cell membrane** is composed of phospholipid and protein molecules, which gives form to a cell and controls the passage of material into and out of a cell. More specifically, the proteins in the cell membrane provide: 1) structural support; 2) a mechanism of molecule transport across the membrane; 3) enzymatic control of chemical reactions; 4) receptors for hormones and other regulatory molecules; and 5) cellular markers (antigens), which identify the blood and tissue type. The carbohydrate molecules: 1) repel negative objects due to their negative charge; 2) act as receptors for hormones and other regulatory molecules; 3) form specific cell markers which enable like cells to attach and aggregate into tissues; and 4) enter into immune reactions.

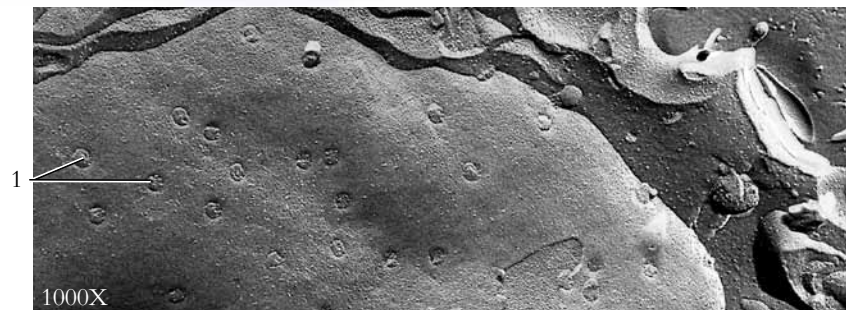
The permeability of the cell membrane is a function of: 1) size of molecules; 2) solubility in lipids; 3) ionic charge of molecules; and 4) the presence of carrier molecules.



**Figure 2.1** A cell and its nucleus and cell (plasma) membrane.



**Figure 2.3** An electron micrograph of a freeze fractured nuclear envelope showing the nuclear pores.



**Table 2.1** Structure and function of cellular components.

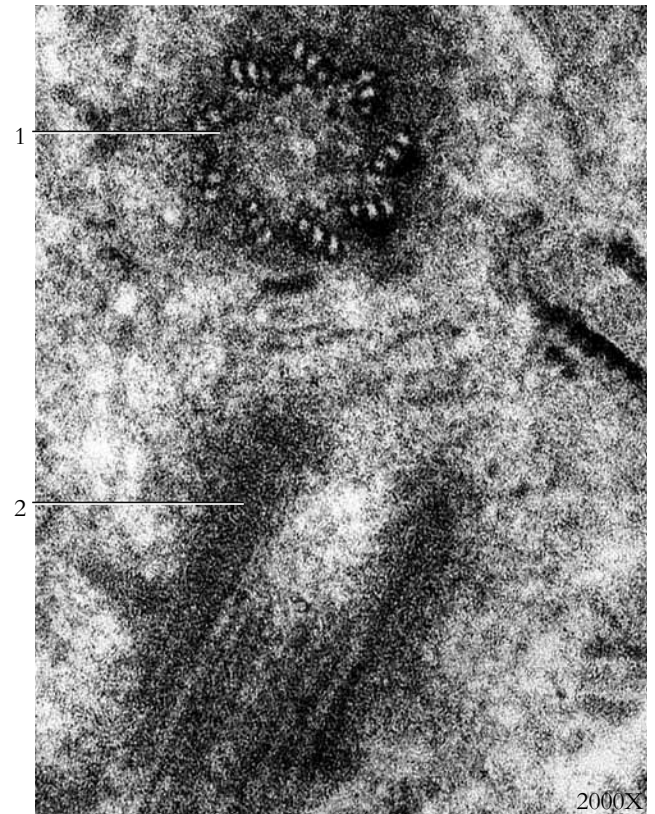
| Component                       | Structure  | Function   |
|---------------------------------|--|--|
| <b>Cell (plasma) membrane</b>   | Composed of protein and phospholipid molecules     | Provides form to cell and controls passage of materials into and out of cell |
| <b>Cytoplasm</b>                | Fluid to jelly-like substance                      | Suspends organelles; a matrix in which chemical reactions occur              |
| <b>Endoplasmic reticulum</b>    | Interconnecting hollow membranous channels         | Provides framework of cell; facilitates cell transport                       |
| <b>Ribosomes</b>                | Granules of ribonucleic acid (RNA)                 | Synthesize proteins  |
| <b>Mitochondria</b>             | Double-layered sacs with cristae                   | Production of ATP in aerobic respiration                                     |
| <b>Golgi complex</b>            | Flattened sacs with vacuoles                       | Synthesize carbohydrates and packages molecules for secretion                |
| <b>Lysosomes</b>                | Membrane-surrounded sacs of enzymes                | Digest foreign molecules and worn cells                                      |
| <b>Centrosome</b>               | Mass of two rodlike centrioles                     | Organizes spindle fibers and assists mitosis                                 |
| <b>Vacuoles</b>                 | Membranous sacs                                    | Store and excrete substances within the cytoplasm                            |
| <b>Fibrils and microfibrils</b> | Protein strands                                    | Support cytoplasm and transport materials                                    |
| <b>Cilia and flagella</b>       | Cytoplasmic extensions from cell; contains axoneme | Movement of particles along cell surface or move cell                        |
| <b>Nucleus</b>                  | Nuclear membrane, nucleolus, and chromatin (DNA)   | Directs cell activity; forms ribosomes                                       |





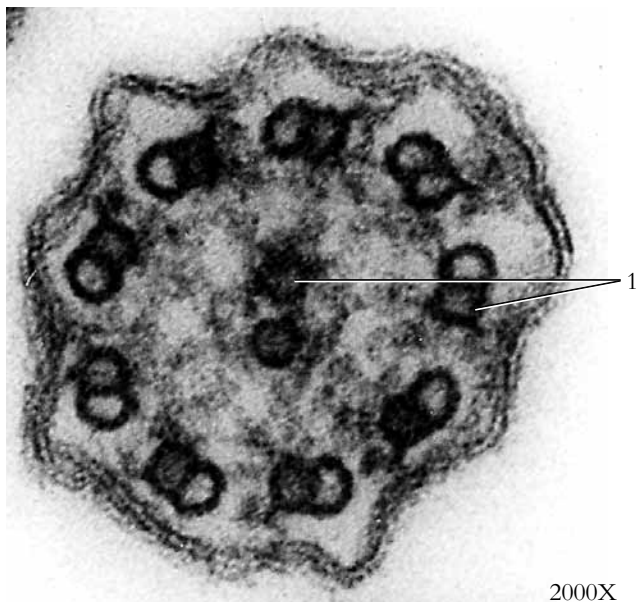
**Figure 2.4** An electron micrograph of various organelles.

- |               |                  |
|---------------|------------------|
| 1. Nucleus    | 3. Mitochondrion |
| 2. Centrioles | 4. Golgi complex |



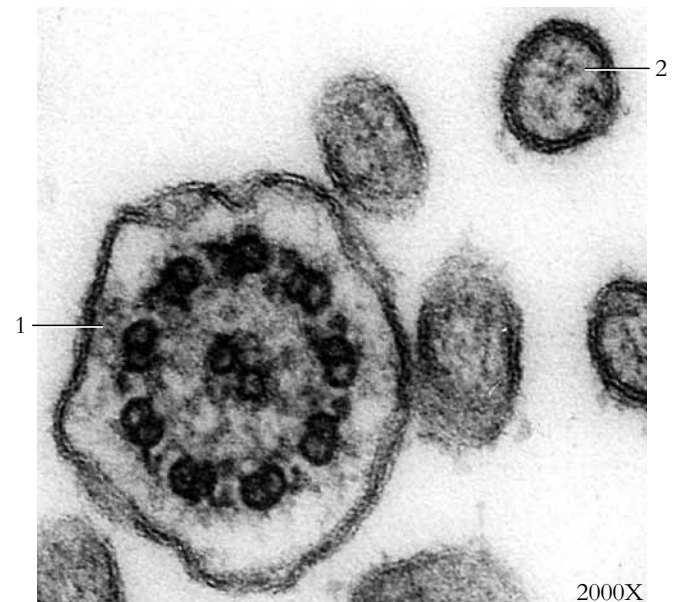
**Figure 2.5** An electron micrograph of centrioles. The centrioles are positioned at right angles to one another.

- |                                       |  |
|---------------------------------------|--|
| 1. Centriole (shown in cross section) | 2. Centriole (shown in longitudinal section) |
|---------------------------------------|--|



**Figure 2.6** An electron micrograph of cilia (cross section) showing the characteristic "9 + 2" arrangement of microtubules in the cross sections.

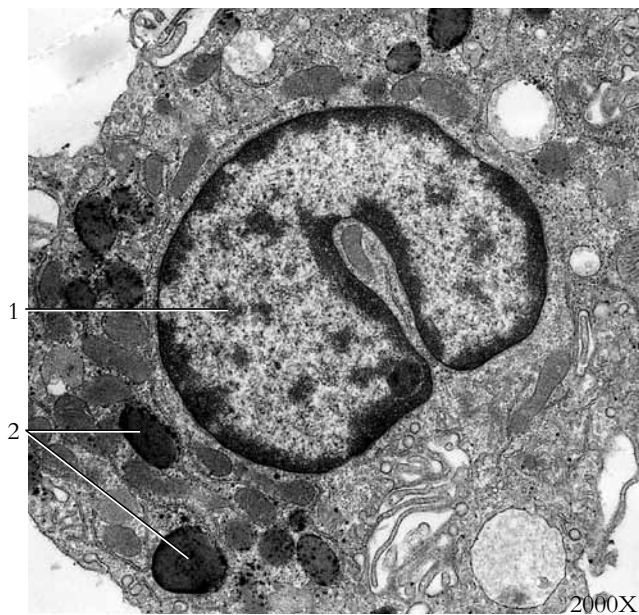
1. Microtubules



**Figure 2.7** An electron micrograph showing the difference between a microvillus and a cilium.

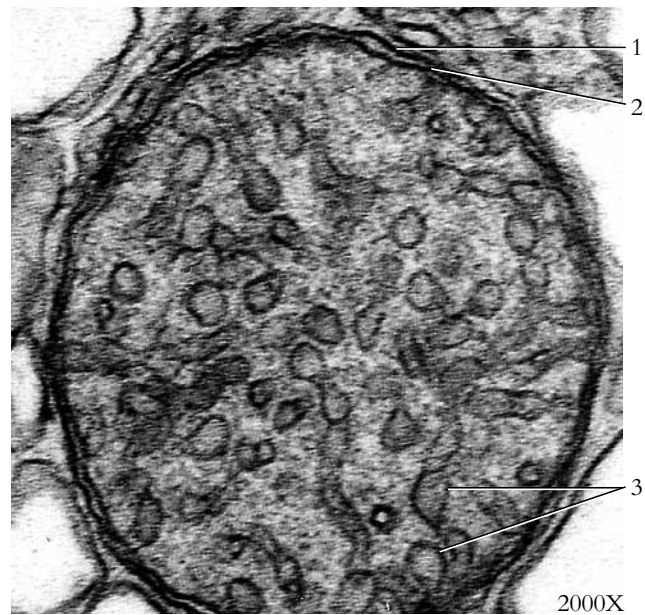
- |           |                |
|-----------|----------------|
| 1. Cilium | 2. Microvillus |
|-----------|----------------|





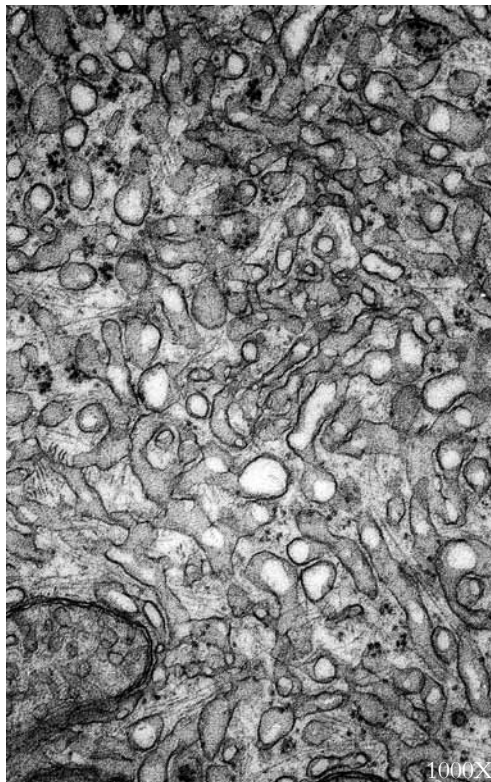
**Figure 2.8** An electron micrograph of lysosomes.

1. Nucleus
2. Lysosomes



**Figure 2.9** An electron micrograph of a mitochondrion.

1. Outer membrane
2. Crista
3. Inner membranes



**Figure 2.10** An electron micrograph of smooth endoplasmic reticulum from the testis.



**Figure 2.11** An electron micrograph of rough endoplasmic reticulum.

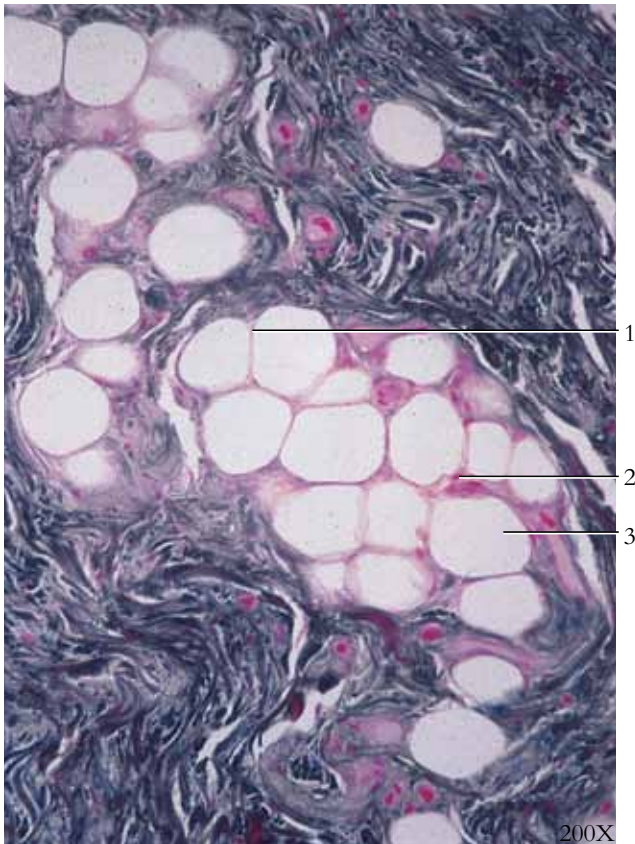
1. Ribosomes
2. Cisternae



**Figure 2.12** Rough endoplasmic reticulum secreting collagenous filaments to the outside of the cell.

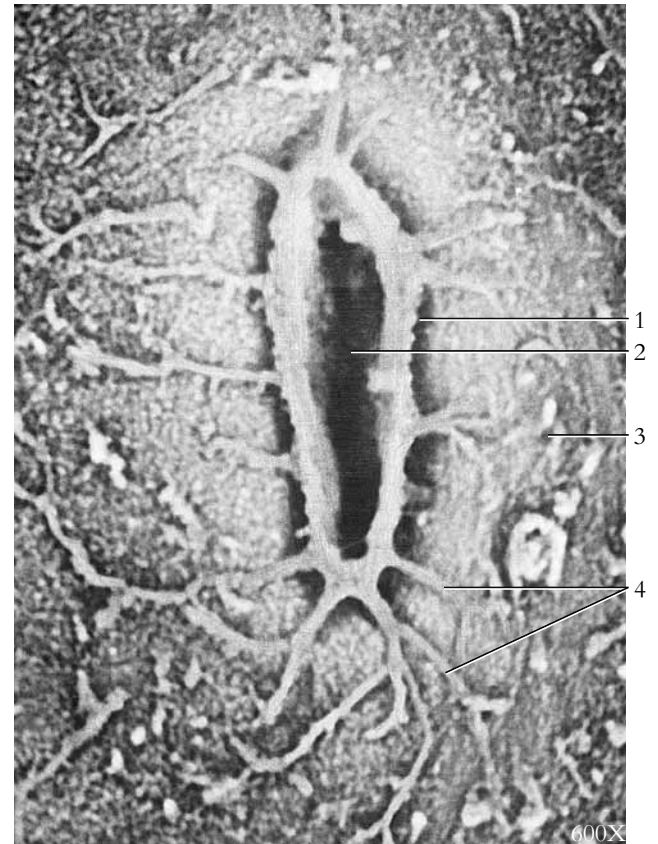
1. Nucleus
2. Rough endoplasmic reticulum
3. Collagenous filaments
4. Cell membrane





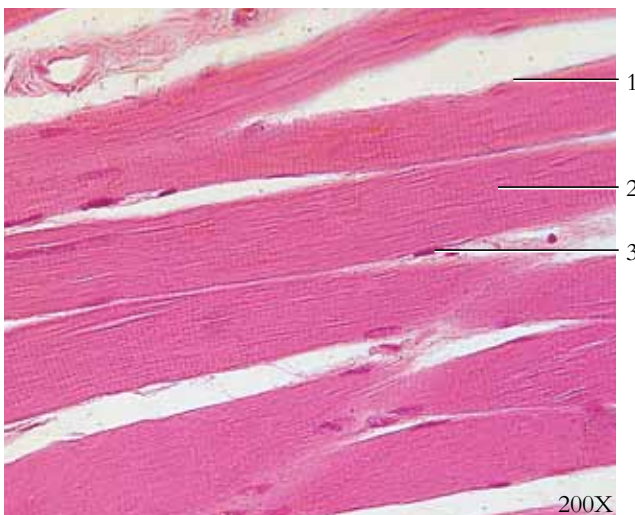
**Figure 2.13** Adipocytes (fat cells) in adipose tissue.

1. Cell membrane of adipocyte
2. Nucleus
3. Lipid-filled vacuole of adipocyte



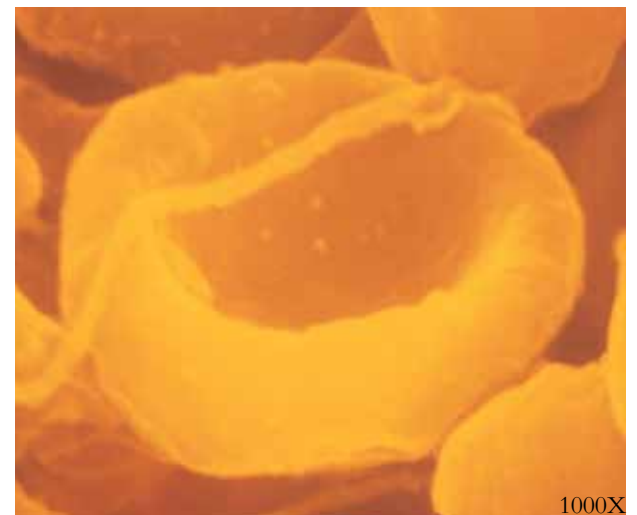
**Figure 2.14** An electron micrograph of an osteocyte (bone cell) in cortical bone matrix.

1. Lacuna
2. Osteocyte
3. Bone matrix
4. Canaliculi

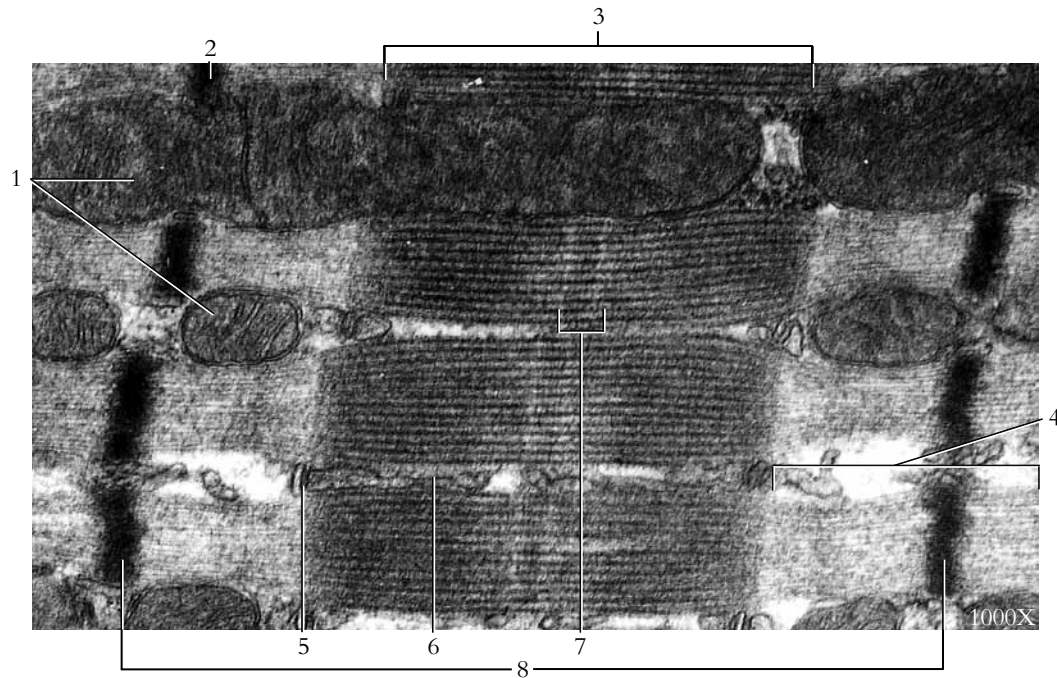


**Figure 2.15** Skeletal muscle cells (fibers).

1. Sarcolemma (cell membrane)
2. Striations
3. Nucleus

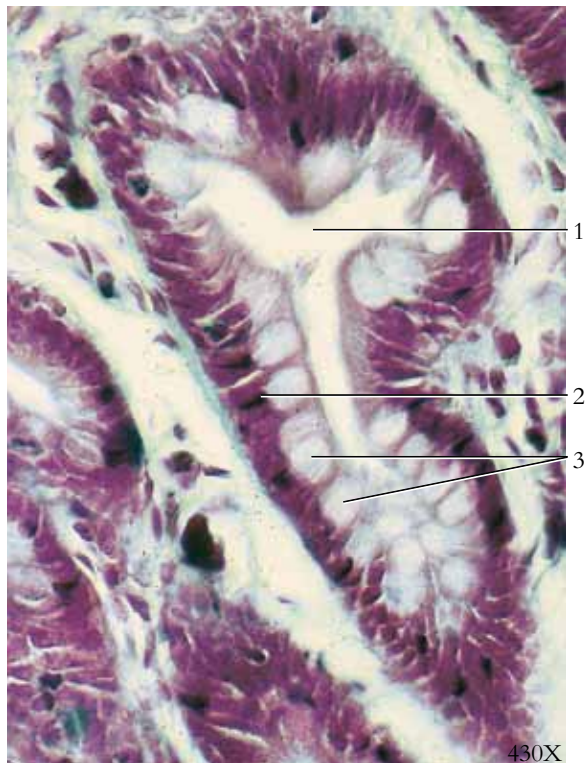


**Figure 2.16** An electron micrograph of an erythrocyte (red blood cell).



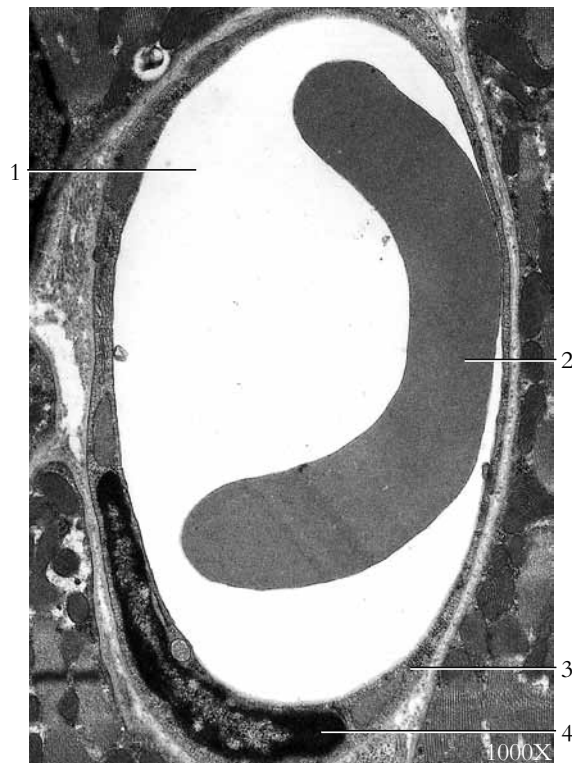
**Figure 2.17** An electron micrograph of a skeletal muscle myofibril, showing the striations.

- |                 |                           |              |
|-----------------|---------------------------|--------------|
| 1. Mitochondria | 4. I band                 | 7. H band    |
| 2. Z line       | 5. T-tubule               | 8. Sacromere |
| 3. A band       | 6. Sarcoplasmic reticulum |              |



**Figure 2.18** Goblet cells within an intestinal gland (crypt of Lieberkühn) of small intestine.

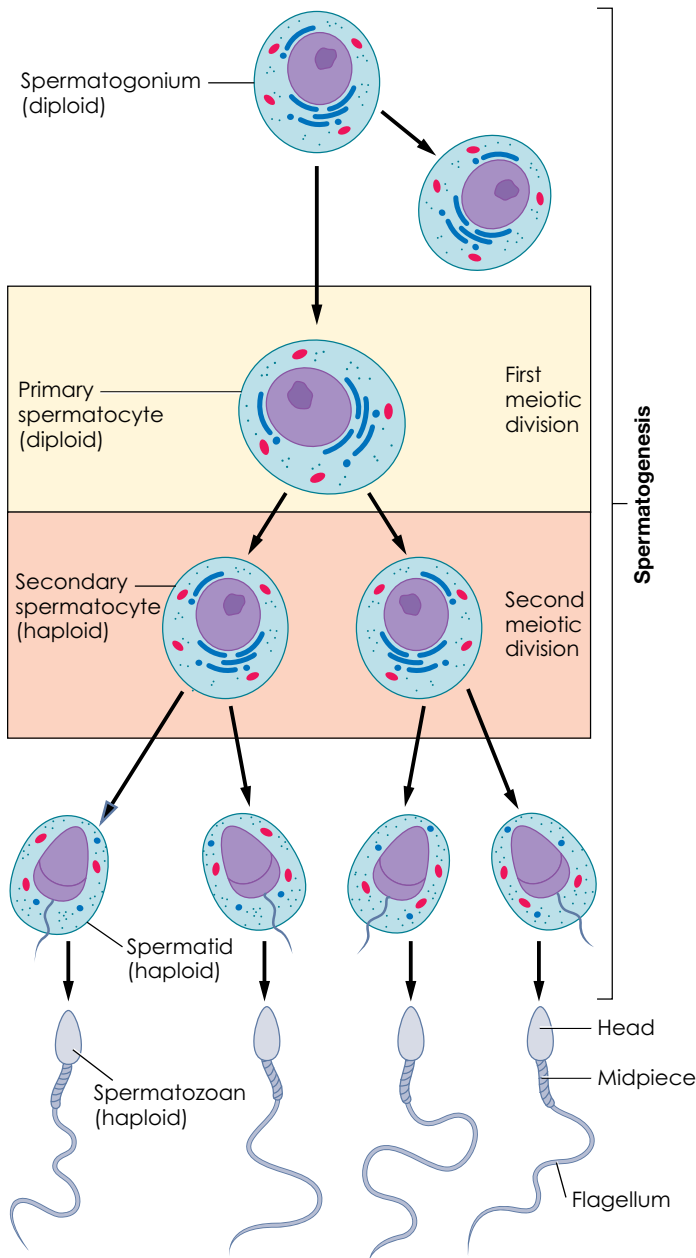
1. Lumen of gland
2. Nucleus
3. Goblet cells



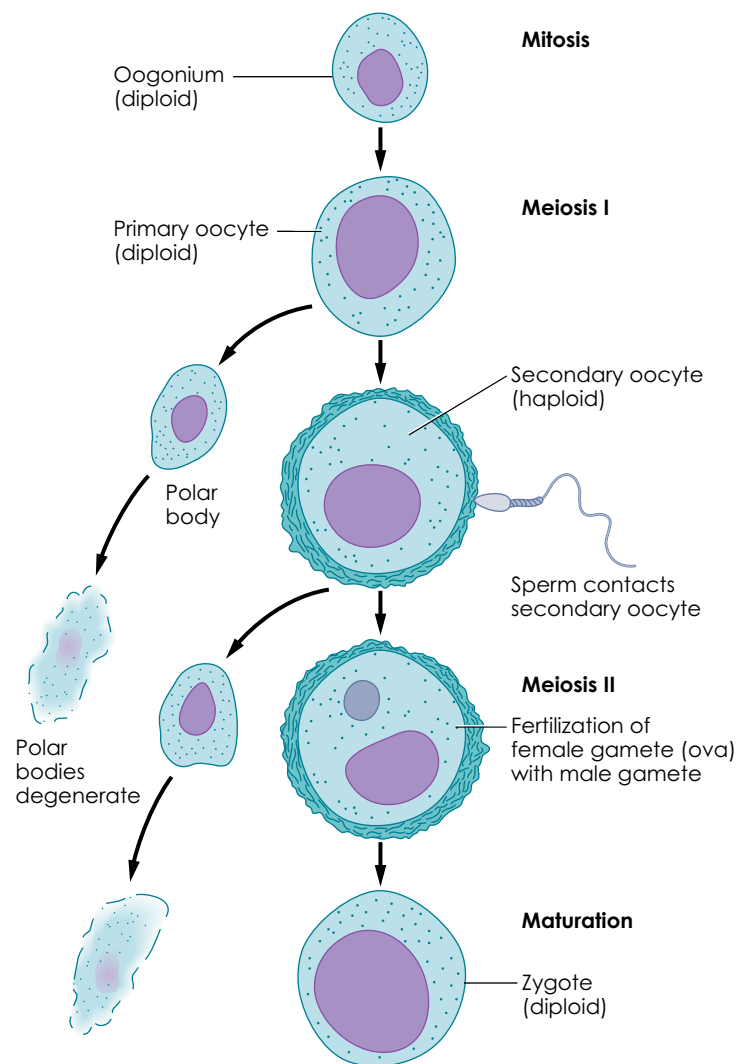
**Figure 2.19** An electron micrograph of a capillary containing an erythrocyte.

- |                       |                                |
|-----------------------|--------------------------------|
| 1. Lumen of capillary | 3. Endothelial cell            |
| 2. Erythrocyte        | 4. Nucleus of endothelial cell |

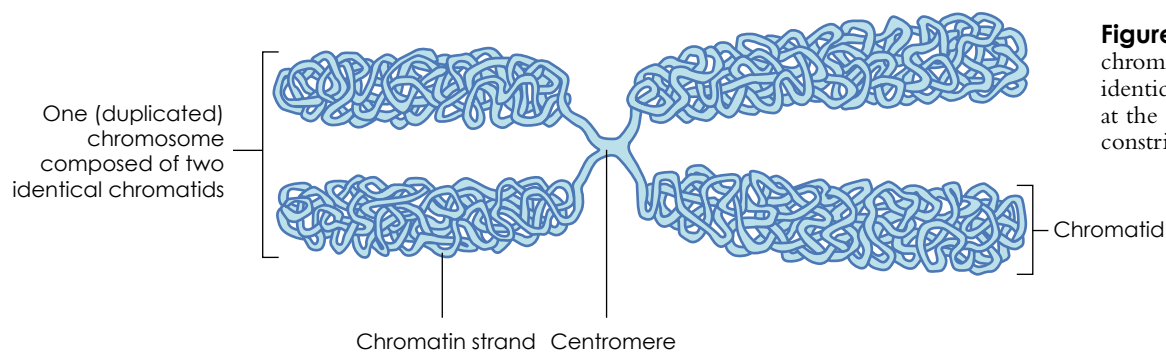




**Figure 2.20** Spermatogenesis is the production of male gametes, or spermatozoa, through the process of meiosis.



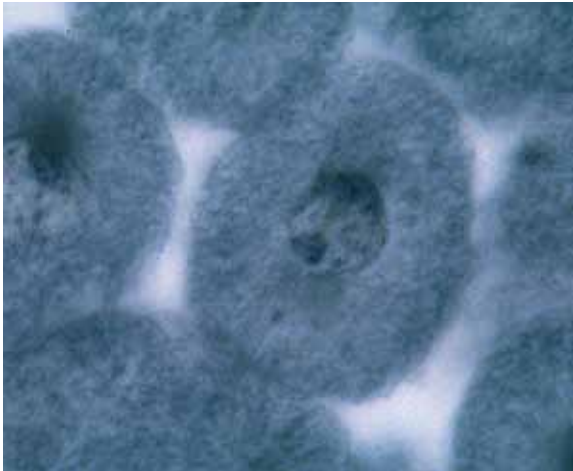
**Figure 2.21** Oogenesis is the production of female gametes, or ova, through the process of meiosis.



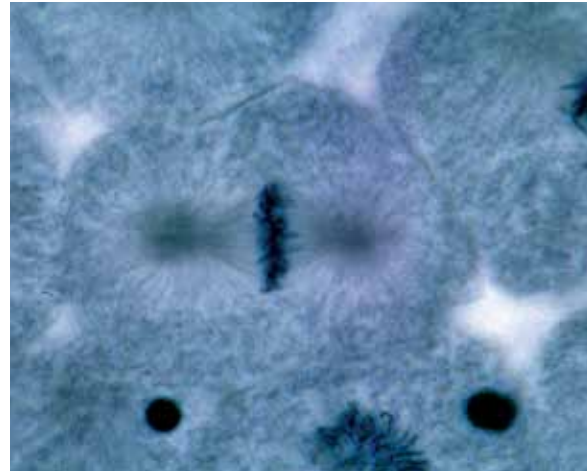
**Figure 2.22** Each duplicated chromosome consists of two identical chromatids attached at the centrally located and constricted centromere.

**Figure 2.23** Stages of mitosis.

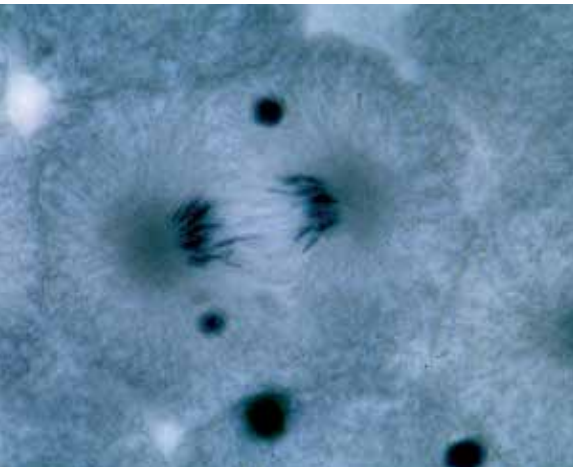
(All photographs on this page are 800X.)



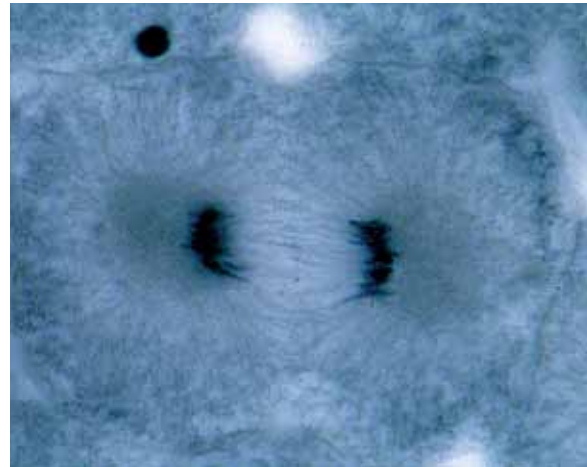
**Prophase** Each chromosome consists of two chromatids joined by a centromere. Spindle fibers extend from each centriole.



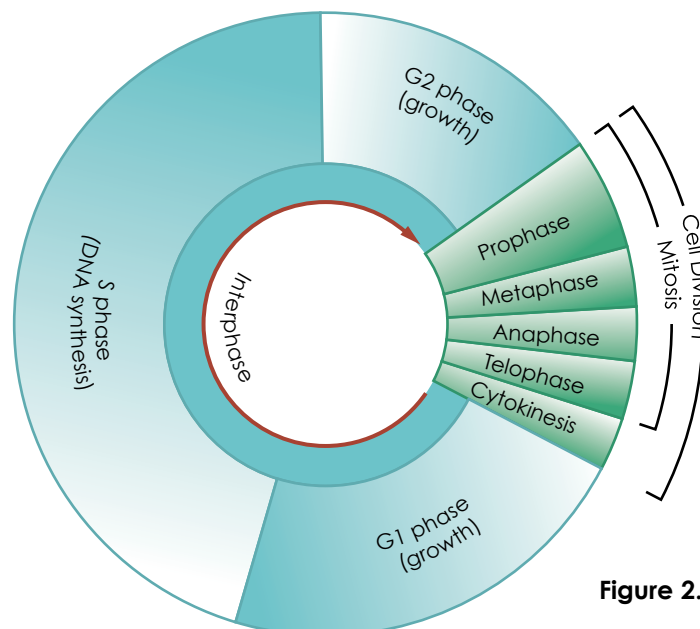
**Metaphase** The chromosomes are positioned at the equator. The spindle fibers from each centriole attach to the centromeres.



**Anaphase** The centromeres split, and the sister chromatids separate as each is pulled to an opposite pole.



**Telophase** The chromosomes lengthen and become less distinct. The cell membrane forms between the forming daughter cells.

**Figure 2.24** The animal cell cycle.



# Chapter 3

## Histology

While it is true that cells comprise the basic structural and functional units of the body, the cells in a multicellular organism, such as a human, are so specialized that they do not function independently. **Tissues** are aggregations of similar cells that perform specific functions. **Histology** is the science concerned with the study of tissues. Both **cytology**, the study of cells, and histology are actually microscopic anatomy. Although cytologists and histologists utilize many different techniques to study cells and tissues, basically only two kinds of microscopes are used to view the prepared specimens. **Light microscopy** is used for the general observation of cellular and tissue structure, and **electron microscopy** permits observation of the fine details of the specimens.

In electron microscopy, a beam of electrons is passed through an object in a procedure called **transmission electron microscopy (TEM)**, or the beam is reflected off the surface of an object in a procedure called **scanning electron microscopy (SEM)**. In both cases, the electron beam is magnified with electromagnets. The depth of focus of SEM is much greater than it is with TEM, producing a clear three-dimensional image of cellular or tissue structure. The magnification ability of SEM, however, is not as great as that of TEM.

The tissues of the body are classified into four principal types, determined by structure and function: 1) **epithelial tissues** cover body and organ surfaces, line body and luminal (hollow portion of body tubes) cavities, and form various glands; 2) **connective tissues** bind, support, and protect body parts; 3) **muscle tissues** contract to produce movements; and 4) **nervous tissues** initiate and transmit nerve impulses from one body part to another.

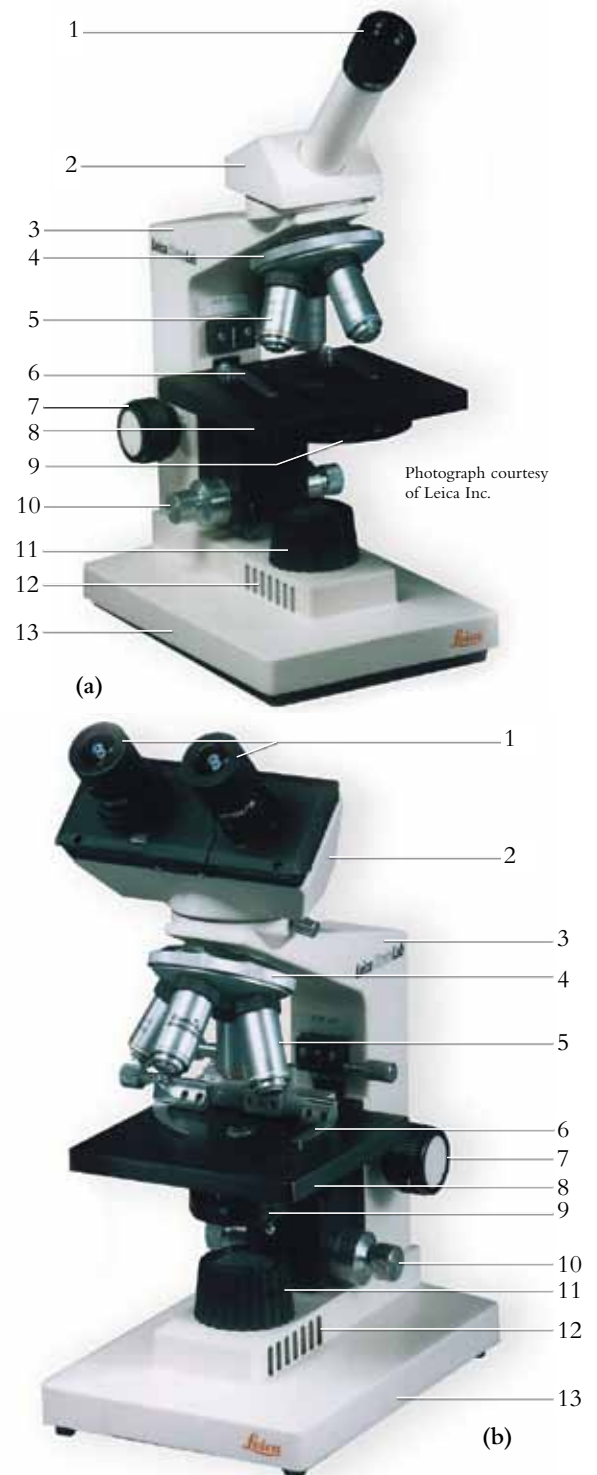
Epithelial tissues are classified by the number of layers of cells and the shapes of the cells along the exposed surfaces. A **simple epithelial tissue** is made up of a single layer of cells. A **stratified epithelial tissue** is made up of layers of cells. The basic shapes of the exposed cells are: **squamous**, or flattened; **cuboidal**, or cube-shaped; and **columnar**, or elongated.

Connective tissues are classified according to the characteristics of the **matrix**, or binding material between the similar cells. The classification of connective tissues is not exact, but the following is a commonly accepted scheme of classification:

- A. Embryonic connective tissue
- B. Connective tissue proper
  - 1. Loose (areolar) connective tissue
  - 2. Dense regular connective tissue
  - 3. Dense irregular connective tissue
  - 4. Elastic connective tissue
  - 5. Reticular connective tissue
  - 6. Adipose tissue
- C. Cartilage
  - 1. Hyaline cartilage
  - 2. Fibrocartilage
  - 3. Elastic cartilage
- D. Bone tissue
- E. Blood (vascular tissue)

Muscle tissues are responsible for the movement of materials through the body, the movement of one part of the body with respect to another, and for locomotion. The three kinds of muscle tissue are **smooth**, **cardiac**, and **skeletal**. The fibers in all three kinds are adapted to contract in response to stimuli.

Nervous tissues are composed of **neurons**, which respond to stimuli and conduct action potentials (nerve impulses) to and from all body organs, and **neuroglia**, which functionally support and physically bind neurons.



**Figure 3.1** Light microscopes, (a) compound monocular microscope, and (b) compound binocular microscope.

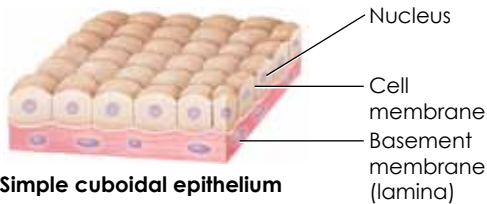
- |                          |   |
|--------------------------|---|
| 1. Eyepiece (ocular)     | 8. Stage                                |
| 2. Body                  | 9. Condenser                            |
| 3. Arm                   | 10. Fine focus adjustment knob          |
| 4. Nosepiece             | 11. Collector lens with field diaphragm |
| 5. Objective             | 12. Illuminator (inside)                |
| 6. Stage clip            | 13. Base                                |
| 7. Focus adjustment knob |   |

## Epithelial Tissue

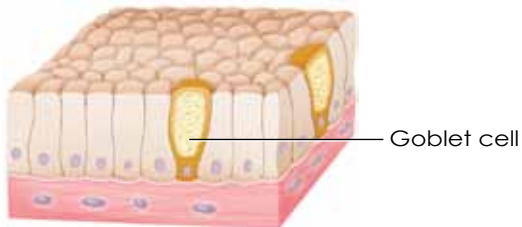
Epithelial tissue covers the outside of the body and lines all organs. Its primary function is to provide protection.



**Simple squamous epithelium**



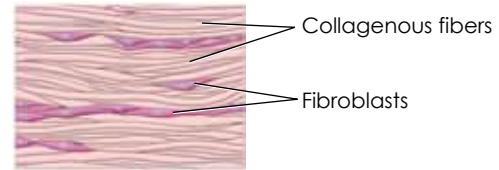
**Simple cuboidal epithelium**



**Simple columnar epithelium**

## Connective Tissue

Connective tissue functions as a binding and supportive tissue for all other tissues in the organism.



**Dense regular connective tissue**



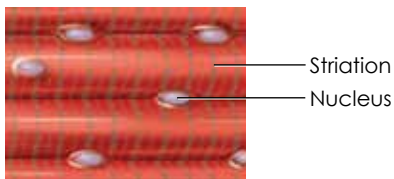
**Adipose tissue**



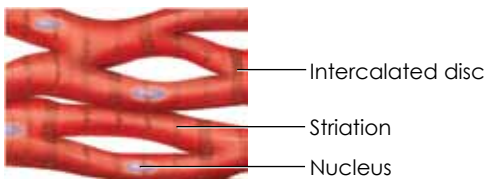
**Bone tissue**

## Muscle Tissue

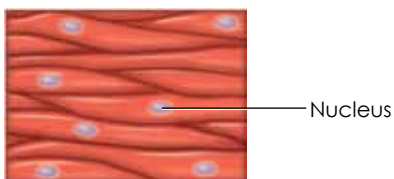
Muscle tissue is a tissue adapted to contract. Muscles provide movement and functionality to the organism.



**Skeletal muscle**



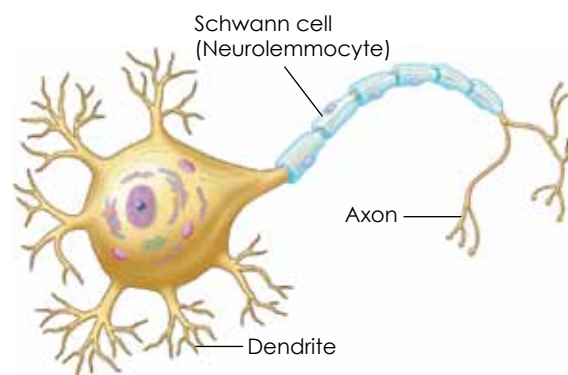
**Cardiac muscle**



**Smooth muscle**

## Nervous Tissue

Nervous tissue functions to receive stimuli and transmits signals from one part of the organism to another.



**Neuron**



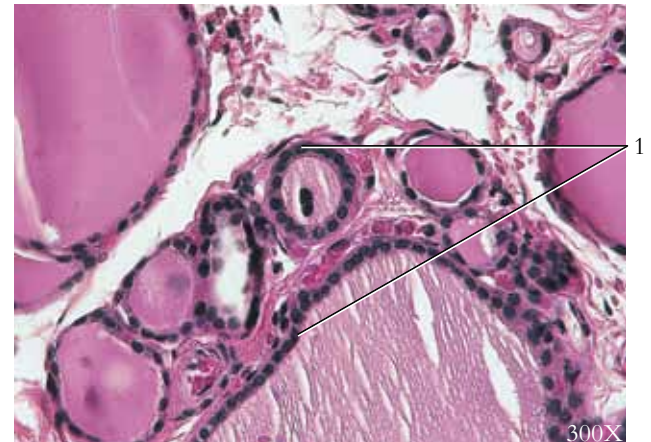
**Neurological cell**

**Figure 3.2** Examples of animal tissues.

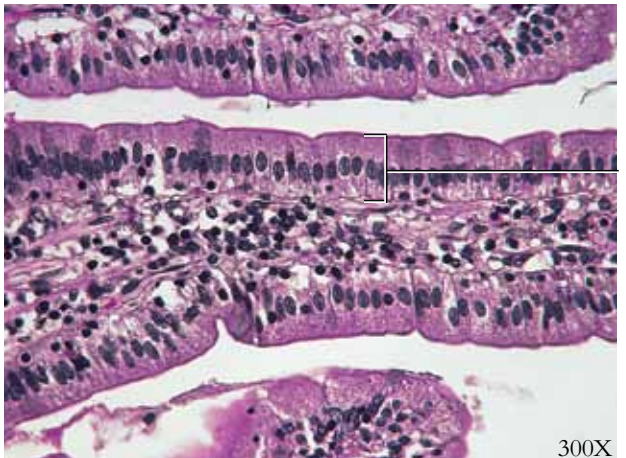




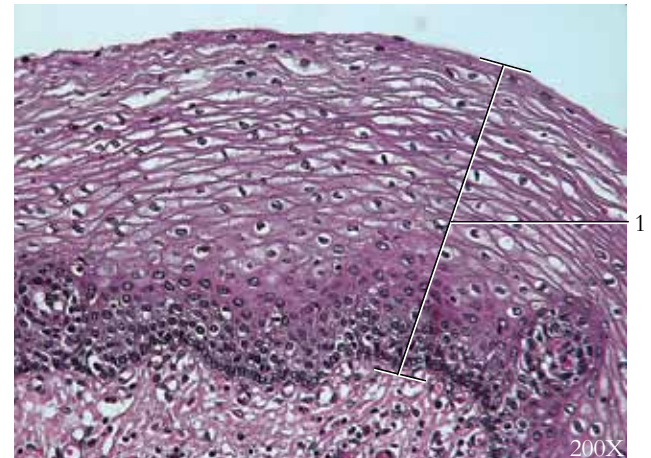
**Figure 3.3** Simple squamous epithelium.  
1. Single layer of flattened cells



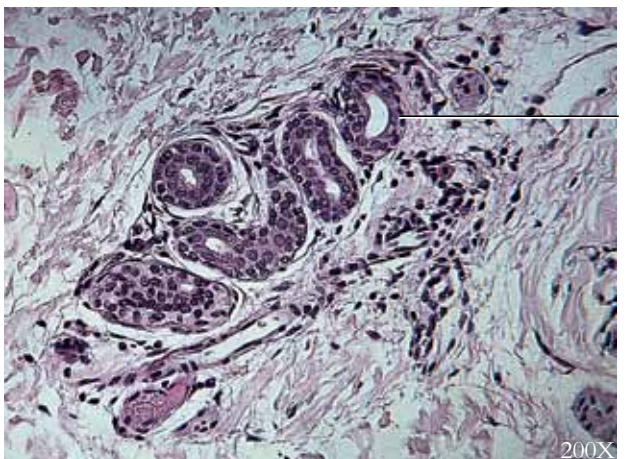
**Figure 3.4** Simple cuboidal epithelium.  
1. Single layer of cells with round nuclei



**Figure 3.5** Simple columnar epithelium.  
1. Single layer of cells with oval nuclei



**Figure 3.6** Stratified squamous epithelium.  
1. Multiple layers of cells, which are flattened at the upper layer

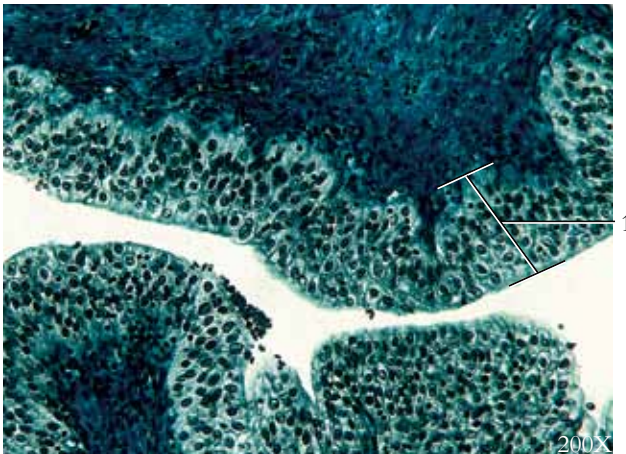


**Figure 3.7** Stratified cuboidal epithelium.  
1. Two layers of cells with round nuclei

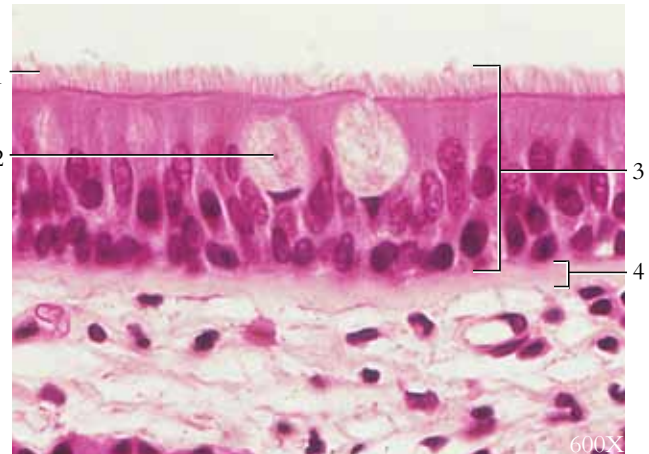


**Figure 3.8** Stratified columnar epithelium.  
1. Two layers of cells with oval nuclei  
2. Lumen

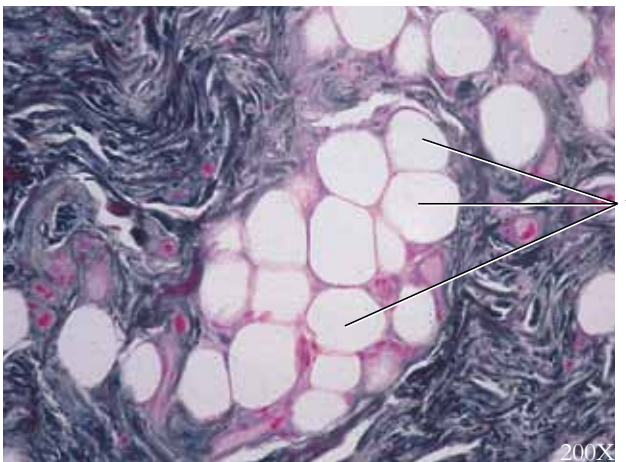




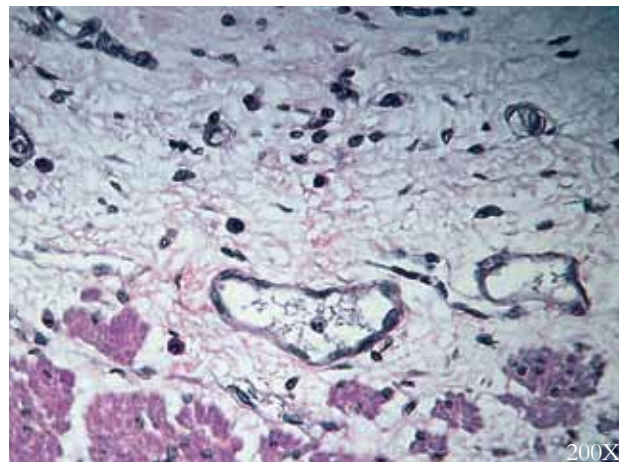
**Figure 3.9** Transitional epithelium.  
1. Cells are balloon-like at surface



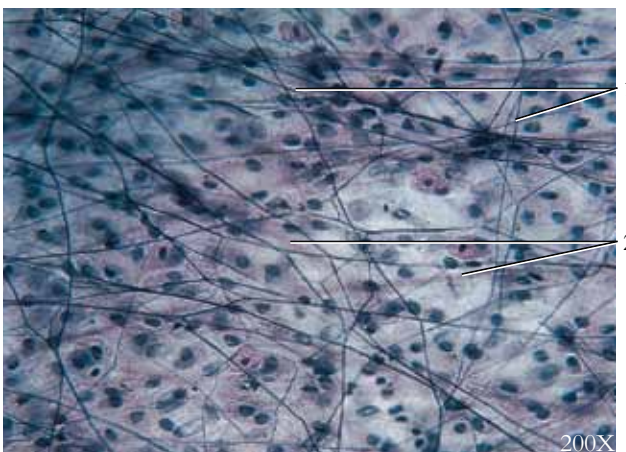
**Figure 3.10** Pseudostratified columnar epithelium.  
1. Cilia  
2. Goblet cell  
3. Pseudostratified columnar epithelium  
4. Basement membrane



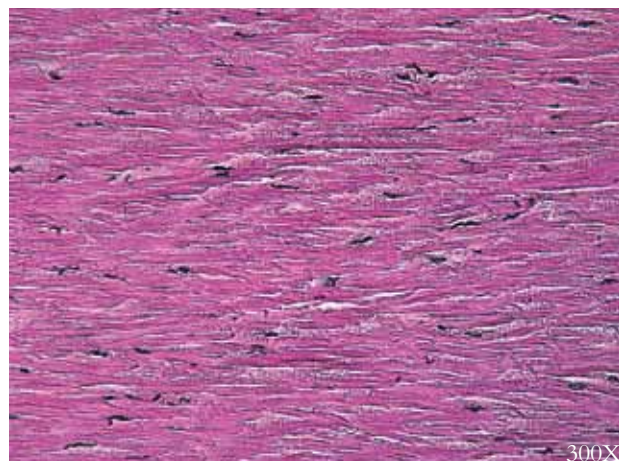
**Figure 3.11** Adipose connective tissue.  
1. Adipocytes (adipose cells)



**Figure 3.12** Loose connective tissue.

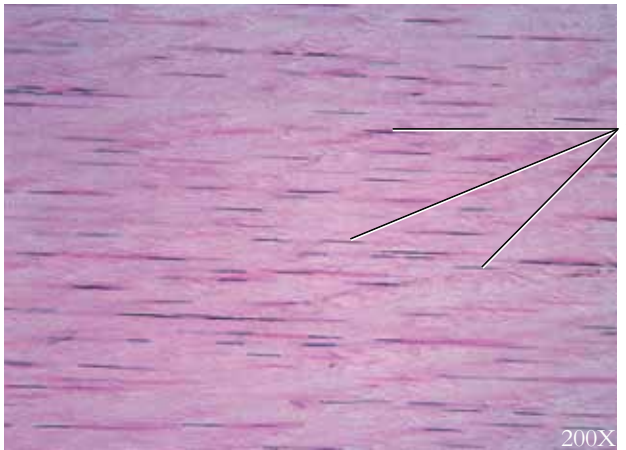


**Figure 3.13** Loose connective tissue stained for fibers.  
1. Elastic fibers (black)  
2. Collagen fibers (pink)



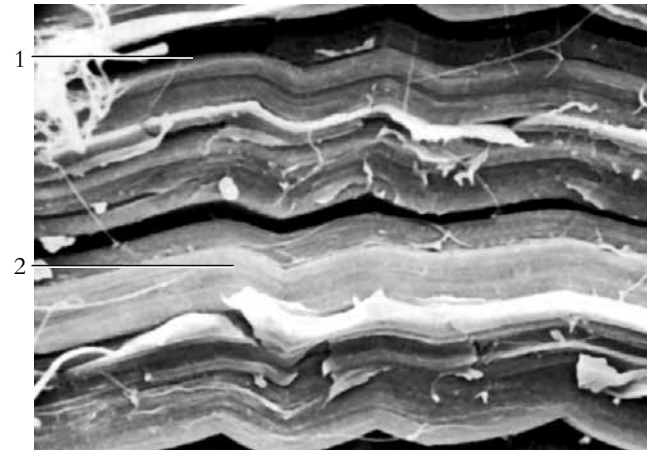
**Figure 3.14** Dense irregular connective tissue.



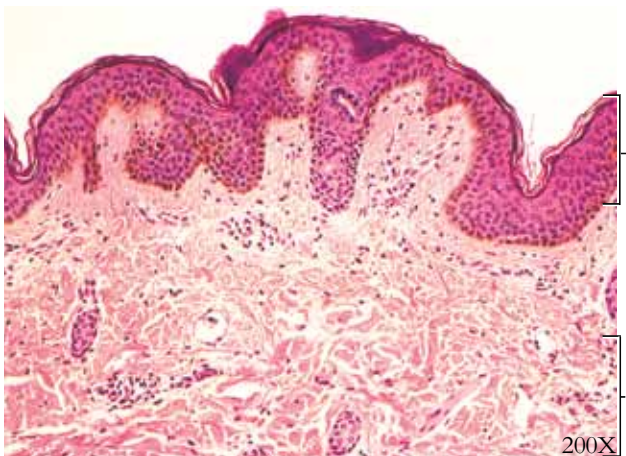


**Figure 3.15** Dense regular connective tissue.  
1. Nuclei of fibroblasts arranged in parallel rows

Electron micrographs courtesy of Scott C. Miller



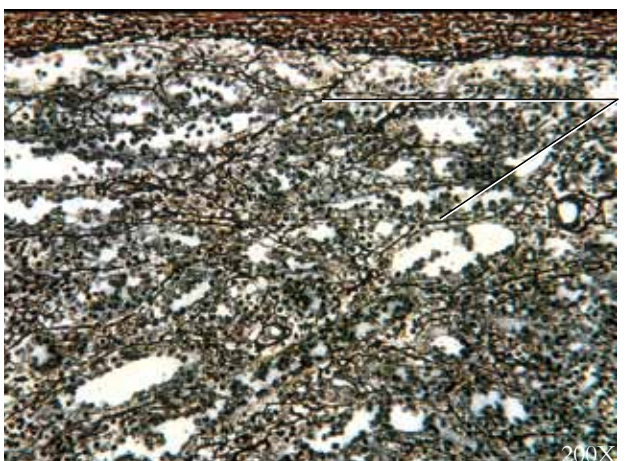
**Figure 3.16** An electron micrograph of dense regular connective tissue.  
1. Collagenous fiber  
2. Fibroblast



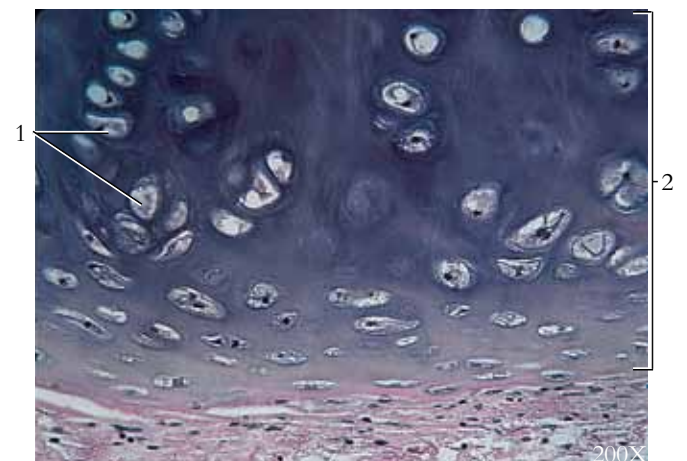
**Figure 3.17** Dense irregular connective tissue.  
1. Epidermis  
2. Dense irregular connective tissue (reticular layer of dermis)



**Figure 3.18** An electron micrograph of dense irregular connective tissue.  
1. Collagenous fibers

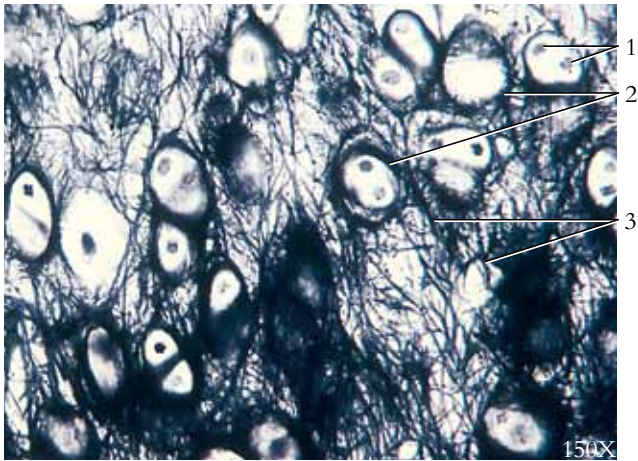


**Figure 3.19** Reticular connective tissue.  
1. Reticular fibers



**Figure 3.20** Hyaline cartilage.  
1. Chondrocytes  
2. Hyaline cartilage

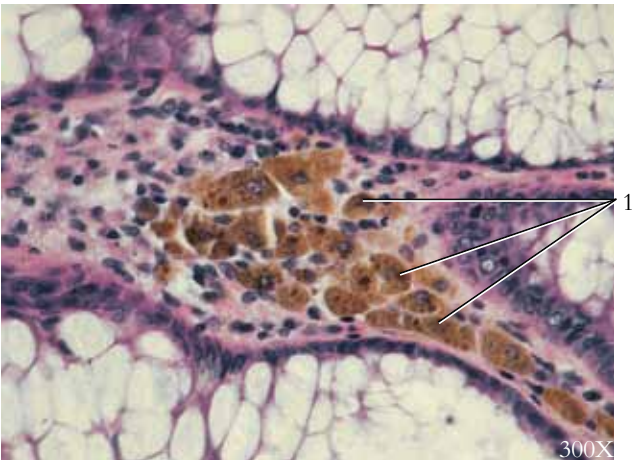



**Figure 3.21** Elastic cartilage.

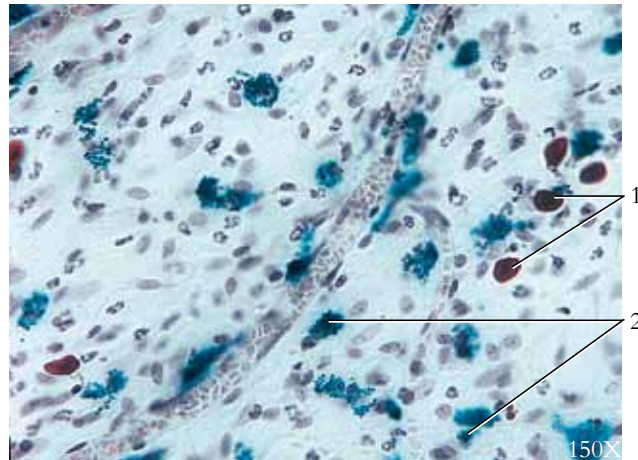
1. Chondrocytes
2. Lacunae
3. Elastic fibers


**Figure 3.22** Fibrocartilage.

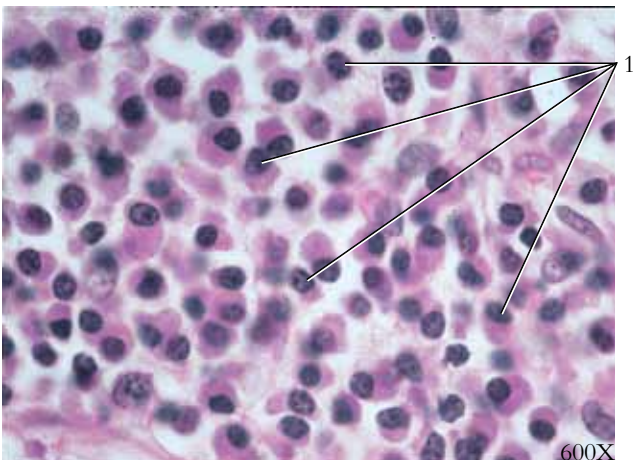
1. Chondrocytes arranged in a row


**Figure 3.23** Cells of connective tissue.

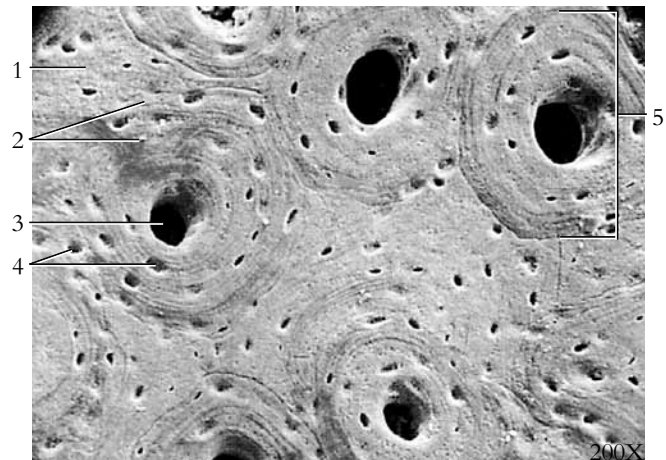
1. Macrophages


**Figure 3.24** Cells of connective tissue, special preparation.

1. Mast cells
2. Macrophages


**Figure 3.25** Cells of connective tissue.

1. Plasma cells


**Figure 3.26** An electron micrograph of bone tissue.

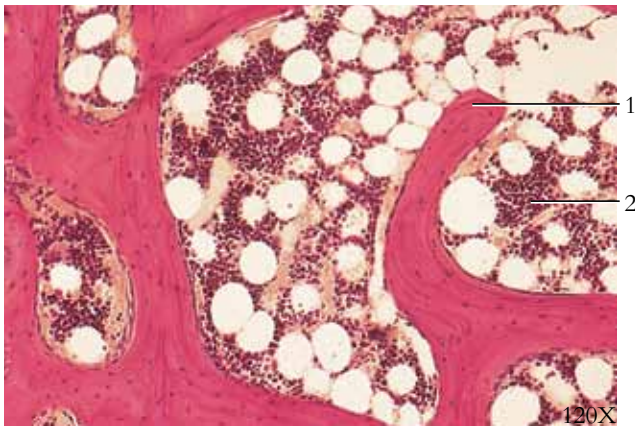
1. Interstitial lamellae
2. Lamellae
3. Central canal (haversian canal)
4. Lacunae
5. Osteon (haversian system)





**Figure 3.27** Cross section of two osteons in bone tissue.

- |                               |               |
|-------------------------------|---------------|
| 1. Osteocytes within lacunae  | 3. Canaliculi |
| 2. Central (haversian) canals | 4. Lamella    |



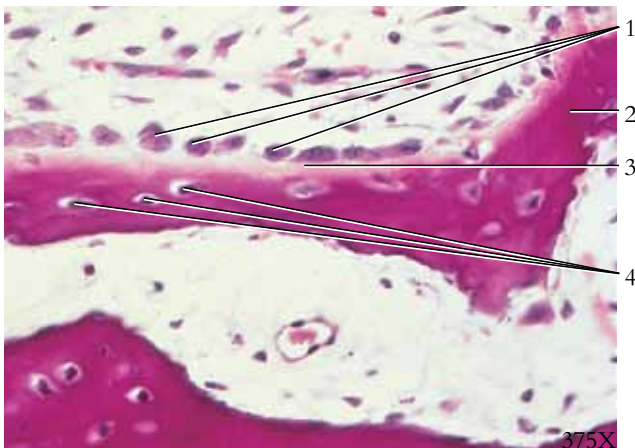
**Figure 3.28** Spongy (cancellous) bone.

- |                                    |
|------------------------------------|
| 1. Spicule of bone                 |
| 2. Marrow (includes adipose cells) |



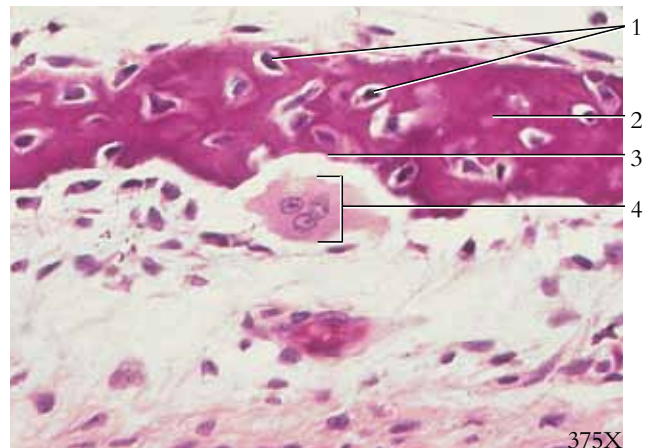
**Figure 3.29** Longitudinal section of osteons.

- |                                   |
|-----------------------------------|
| 1. Central (haversian) canal      |
| 2. Perforating (Volkman's) canals |
| 3. Central (haversian) canals     |



**Figure 3.30** Osteoblasts.

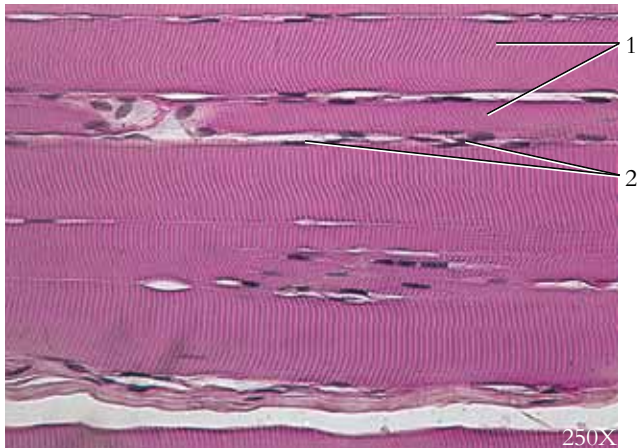
- |                |               |
|----------------|---------------|
| 1. Osteoblasts | 3. Osteoid    |
| 2. Bone        | 4. Osteocytes |



**Figure 3.31** Osteoclast.

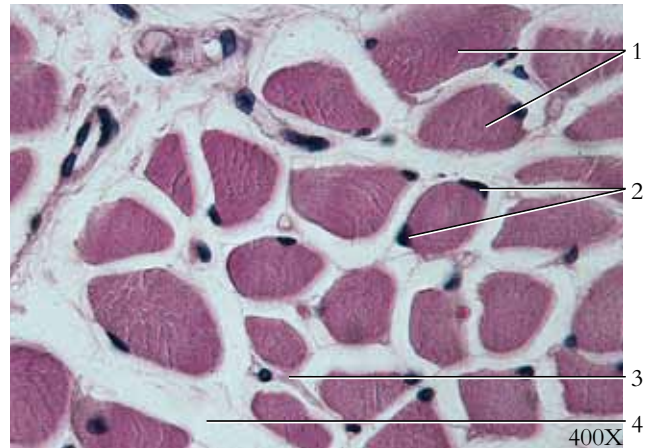
- |                     |                                   |
|---------------------|-----------------------------------|
| 1. Osteocytes       | 4. Osteoclast in Howship's lacuna |
| 2. Bone             |                                   |
| 3. Howship's lacuna |                                   |





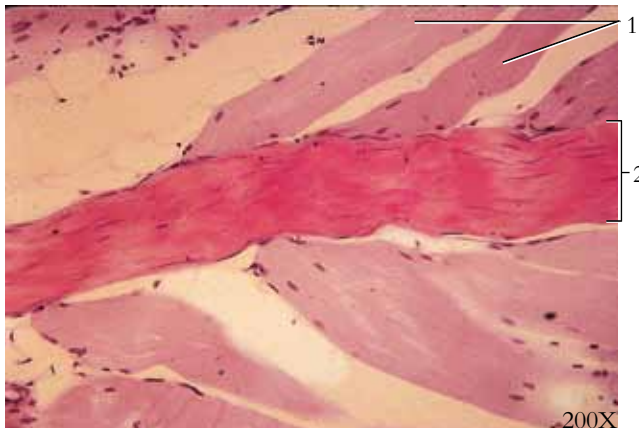
**Figure 3.32** Longitudinal section of skeletal muscle tissue.

1. Skeletal muscle cells, note striations
2. Multiple nuclei in periphery of cell



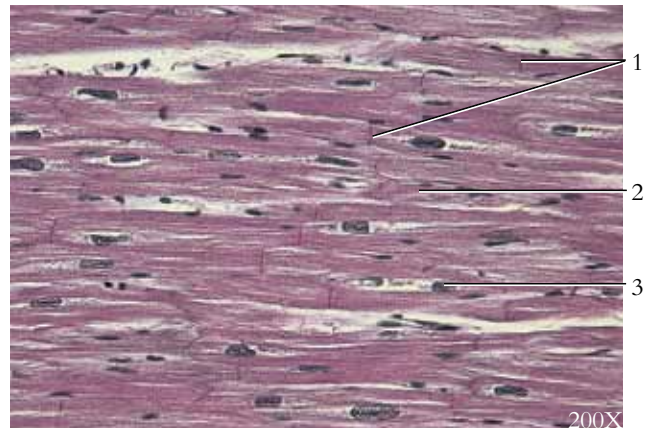
**Figure 3.33** Cross section of skeletal muscle tissue.

1. Skeletal muscle cells
2. Nuclei in periphery of cell
3. Endomysium (surrounds cells)
4. Perimysium (surrounds bundles of cells)



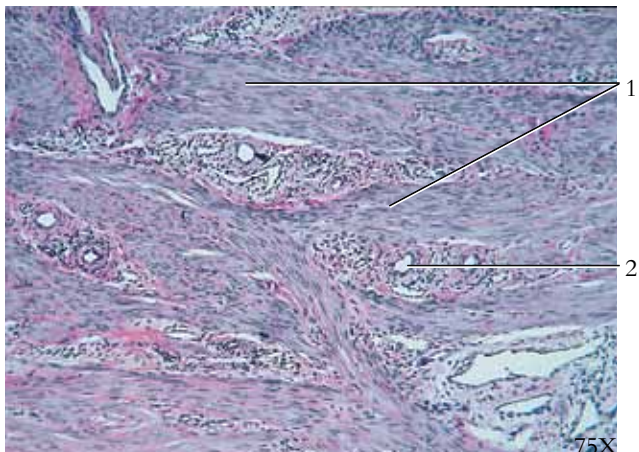
**Figure 3.34** Attachment of skeletal muscle to tendon.

1. Skeletal muscle
2. Dense regular connective tissue (tendon)



**Figure 3.35** Cardiac muscle tissue.

1. Intercalated discs
2. Light-staining perinuclear sarcoplasm
3. Nucleus in center of cell



**Figure 3.36** Smooth muscle tissue.

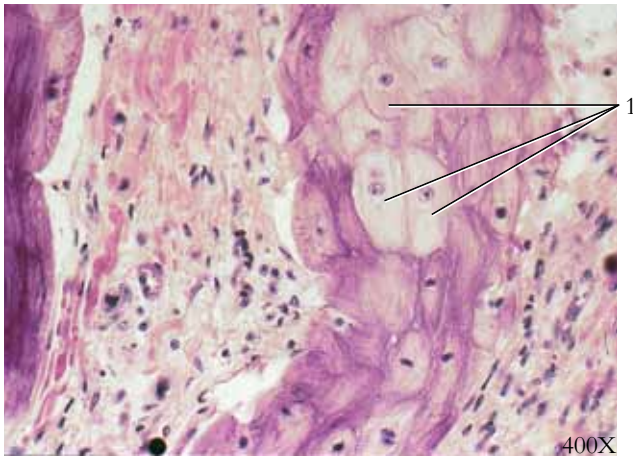
1. Smooth muscle
2. Blood vessel



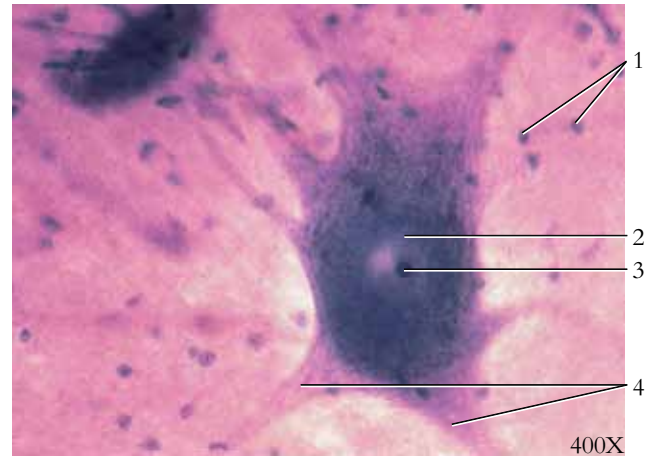
**Figure 3.37** Partially teased smooth muscle tissue.

1. Nucleus of individual cell

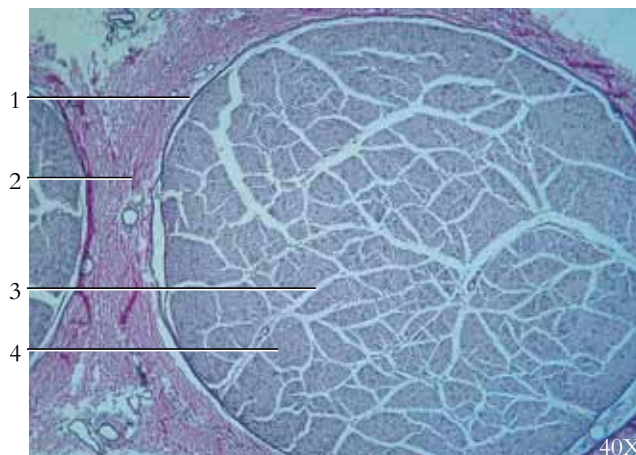




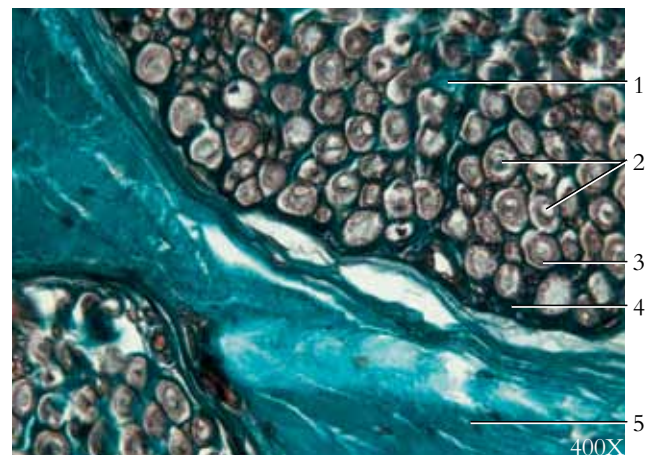
**Figure 3.38** Conduction myofibers (Purkinje fibers).  
1. Conduction myofibers in the heart



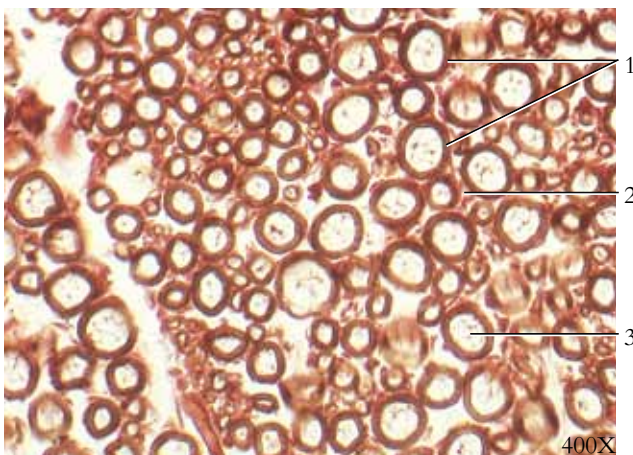
**Figure 3.39** Nervous tissue.  
1. Nuclei of surrounding neuroglial cells  
2. Nucleus of neuron  
3. Nucleolus of neuron  
4. Dendrites of neuron



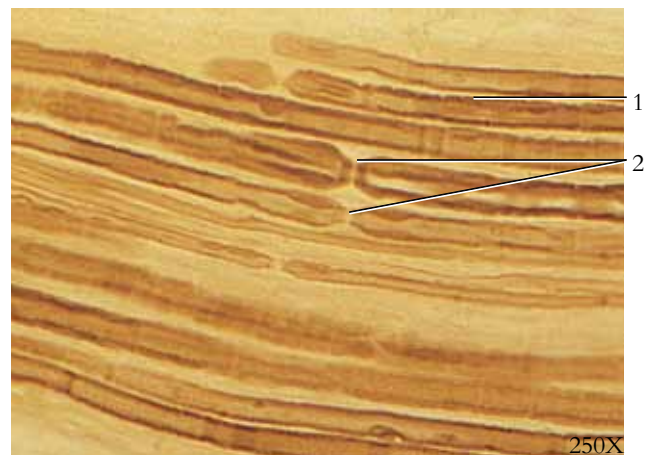
**Figure 3.40** Cross section of a peripheral nerve.  
1. Perineurium 3. Endoneurium  
2. Epineurium 4. Bundle of axons



**Figure 3.41** Cross section of a peripheral nerve.  
1. Endoneurium 3. Myelin sheath 5. Epineurium  
2. Axons 4. Perineurium



**Figure 3.42** A nerve stained with osmium.  
1. Myelin sheath  
2. Endoneurium  
3. Axon



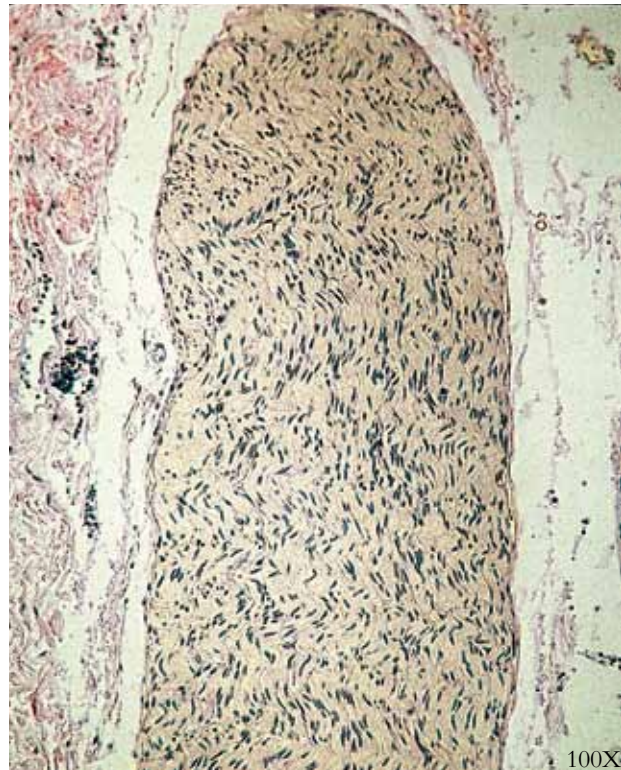
**Figure 3.43** A longitudinal section of axons.  
1. Myelin sheath  
2. Neurofibril nodes (nodes of Ranvier)





**Figure 3.44** Neuromuscular junction.

1. Motor nerve
2. Motor end plates
3. Skeletal muscle fiber



**Figure 3.45** Cross section of unmyelinated nerve.



**Figure 3.46** Cross section of the spinal cord.

1. Posterior (dorsal) root of spinal nerve
2. Posterior (dorsal) horn (gray matter)
3. Spinal cord tract (white matter)
4. Anterior (ventral) horn (gray matter)



**Figure 3.47** Motor neurons from spinal cord.

1. Neuroglia cells
2. Dendrites
3. Nucleus



# Chapter 4

## Integumentary System

The integumentary system consists of the **integument**, or **skin**, and its associated **hair**, **glands**, and **nails** (fig. 4.1). The skin is composed of an outer **epidermis** consisting of numerous layers and a **dermis** consisting of two layers. The **hypodermis** (**subcutaneous tissue**) connects the skin to the underlying organs.

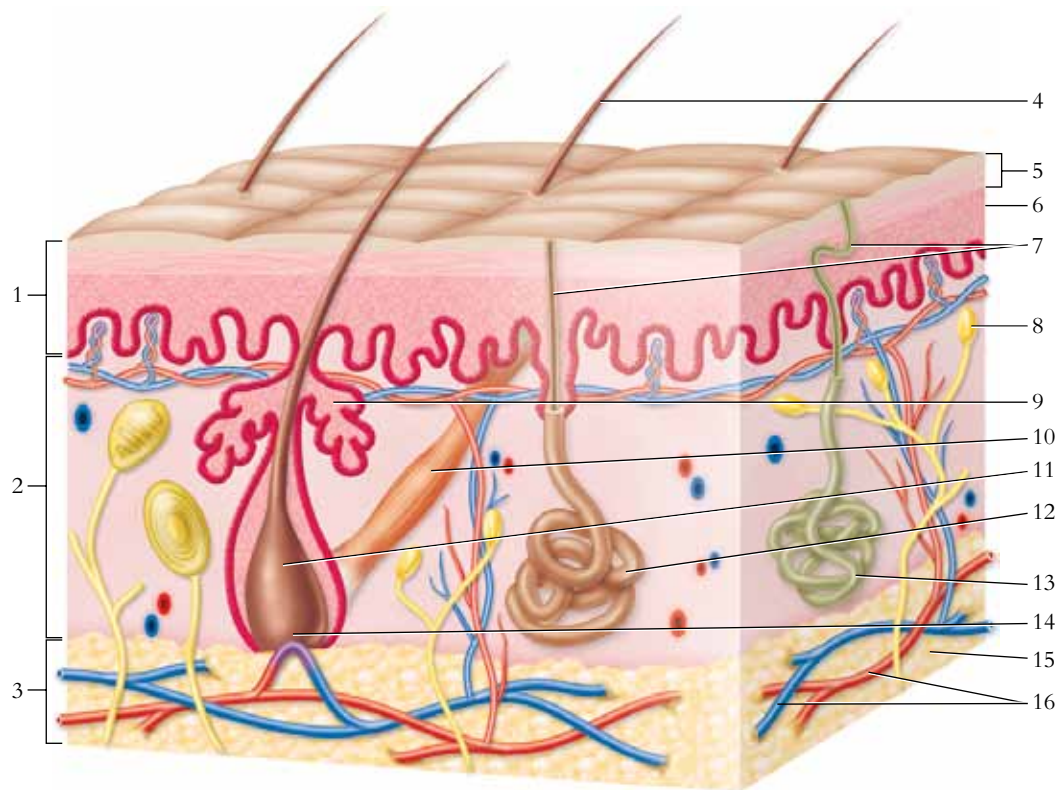
The stratified squamous epithelium of the epidermis is divisible into five **strata**, or layers. From superficial to deep, they are the **stratum corneum**, the **stratum lucidum** (only in skin of the palms and soles), the **stratum granulosum**, the **stratum spinosum**, and the **stratum basale** (**stratum germinativum**). The stratum basale undergoes mitosis (cell division). Pigments, such as **melanin**, are found in the stratum basale and the protein **keratin** is found in all but the deepest epidermal layers. Both are protective. The stratum corneum is **cornified** (hardened and scale-like) for further protection.

The dermis is divisible into the **stratum papillareum** (papillary layer) and the **stratum reticularum** (reticular layer). The hypodermis is the deep, binding layer of connective tissue.

The skin provides several important functions, including: 1) protection of the body from disease and external injury. Keratin and an acidic, oily secretion on the surface protect the skin from

water and microorganisms. Cornification protects against abrasion, and **melanin** (a dark pigment) is a barrier to UV light; 2) regulation of body fluids and temperatures by radiation, convection, and the antagonistic effects of sweating and shivering; 3) permits the absorption of some UV light, respiratory gases, steroids, and fat-soluble vitamins; 4) synthesizes melanin and keratin, which remain in the skin, and vitamin D, which is used elsewhere in the body; 5) sensory reception provided through cutaneous receptors throughout the dermis and hypodermis; and 6) development and growth of hair and certain exocrine glands.

Formed prenatally as invaginations of the epidermis into the dermis, hair, glands, and nails provide protection to the skin. Each hair develops in a **hair follicle** and is protective against sunlight and mild abrasions. Integumentary glands are classified as **sebaceous** (oil secreting), **sudoriferous** (sweat), and **ceruminous** (wax-producing). (**Mammary glands** are specialized sweat glands that produce milk in a lactating female.) A nail protects the terminal end of each digit. The fingernails also aid in picking up objects and scratching.



**Figure 4.1** The skin and certain epidermal structures.

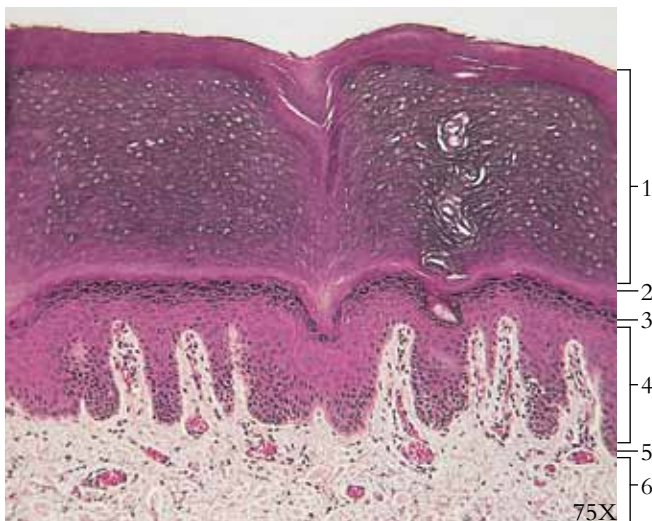
1. Epidermis
2. Dermis
3. Hypodermis
4. Shaft of hair
5. Stratum corneum
6. Stratum basale
7. Sweat duct
8. Sensory receptor
9. Sebaceous gland
10. Arrector pili muscle
11. Hair follicle
12. Apocrine sweat gland
13. Eccrine sweat gland
14. Bulb of hair
15. Adipose tissue
16. Cutaneous blood vessels





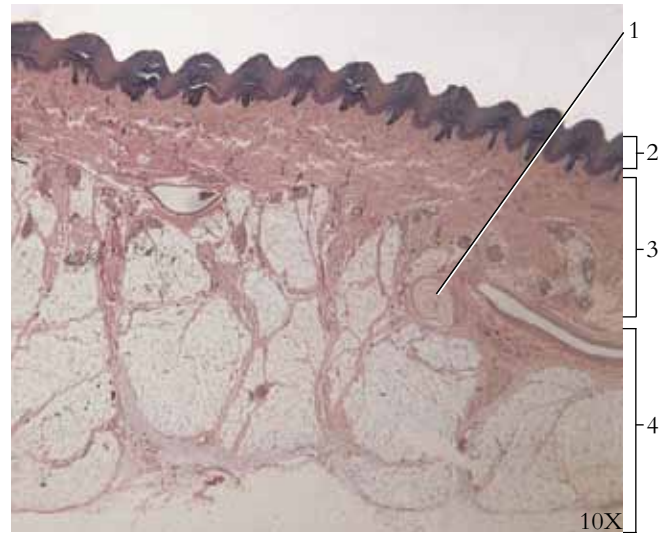
**Figure 4.2** The gross structure of the skin and underlying fascia.

- |               |           |
|---------------|-----------|
| 1. Epidermis  | 4. Fascia |
| 2. Dermis     | 5. Muscle |
| 3. Hypodermis |           |



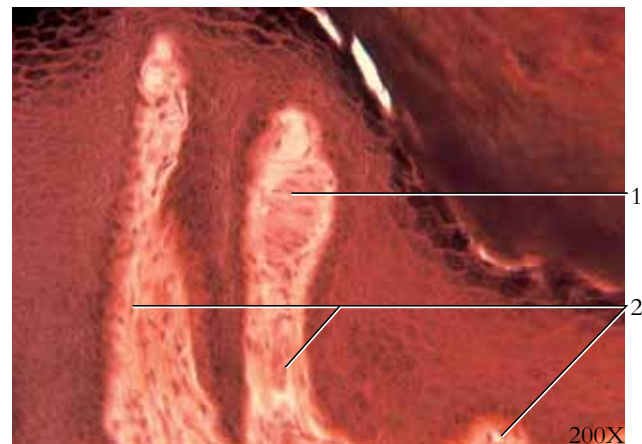
**Figure 4.5** Epidermis and dermis.

- |                       |                     |
|-----------------------|---------------------|
| 1. Stratum corneum    | 4. Stratum spinosum |
| 2. Stratum lucidum    | 5. Stratum basale   |
| 3. Stratum granulosum | 6. Dermis           |



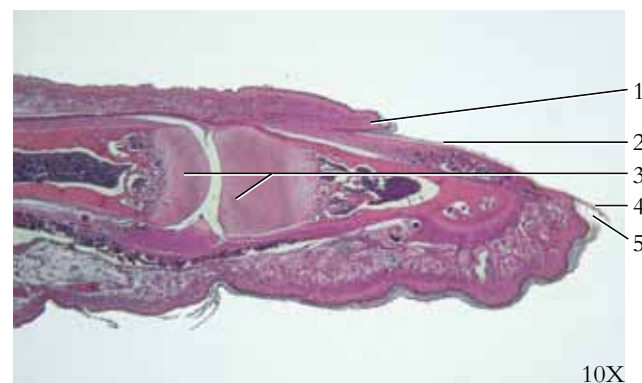
**Figure 4.3** Skin.

- |                                    |               |
|------------------------------------|---------------|
| 1. Lamellated (Pacinian) corpuscle | 3. Dermis     |
| 2. Epidermis                       | 4. Hypodermis |



**Figure 4.4** Corpuscle of touch.

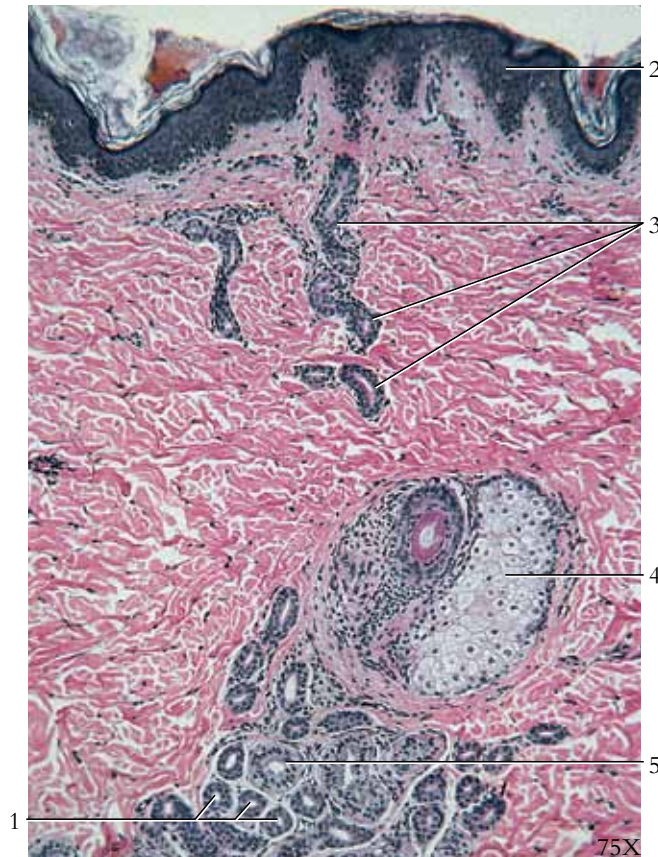
- |  |
|--|
| 1. Corpuscle of touch (Meissner's corpuscle) |
| 2. Dermal papillae                           |



**Figure 4.6** Fingertip.

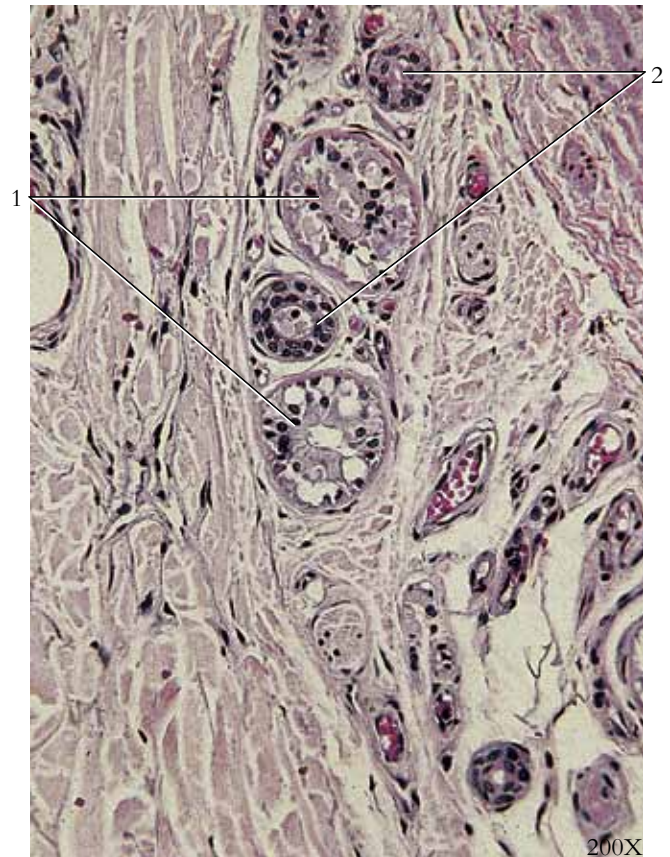
- |               |                        |
|---------------|------------------------|
| 1. Eponychium | 4. Free border of nail |
| 2. Nail plate | 5. Hyponychium         |
| 3. Phalanges  |                        |





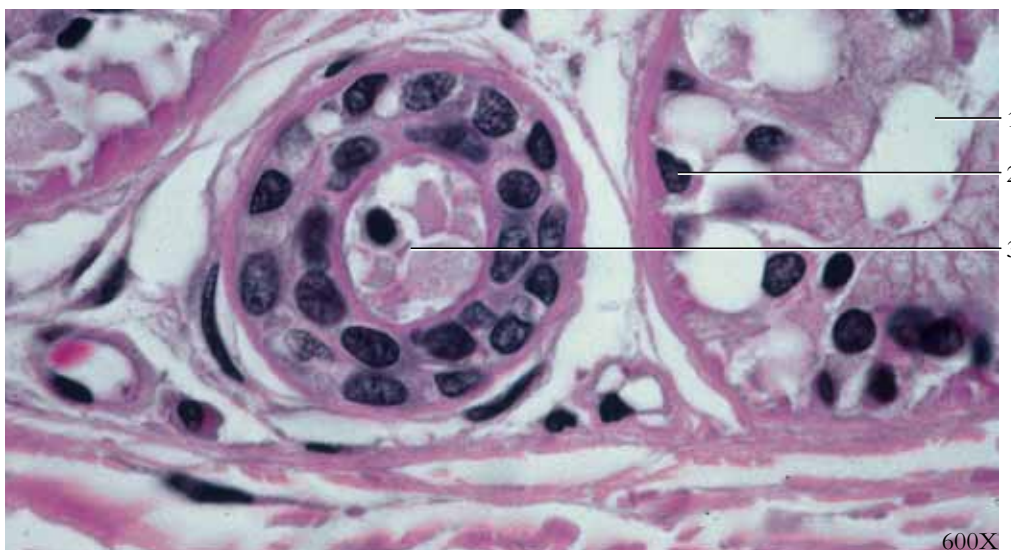
**Figure 4.7** Eccrine sweat gland.

1. Excretory portion of sweat gland
2. Epidermis
3. Excretory duct of sweat gland (coiling toward surface)
4. Sebaceous gland
5. Secretory portion of sweat gland



**Figure 4.8** Sweat gland.

1. Secretory portion  
(large diameter with light-staining columnar cells)
2. Excretory portion  
(small diameter with dark-staining stratified cuboidal cells)



**Figure 4.9** Sweat gland.

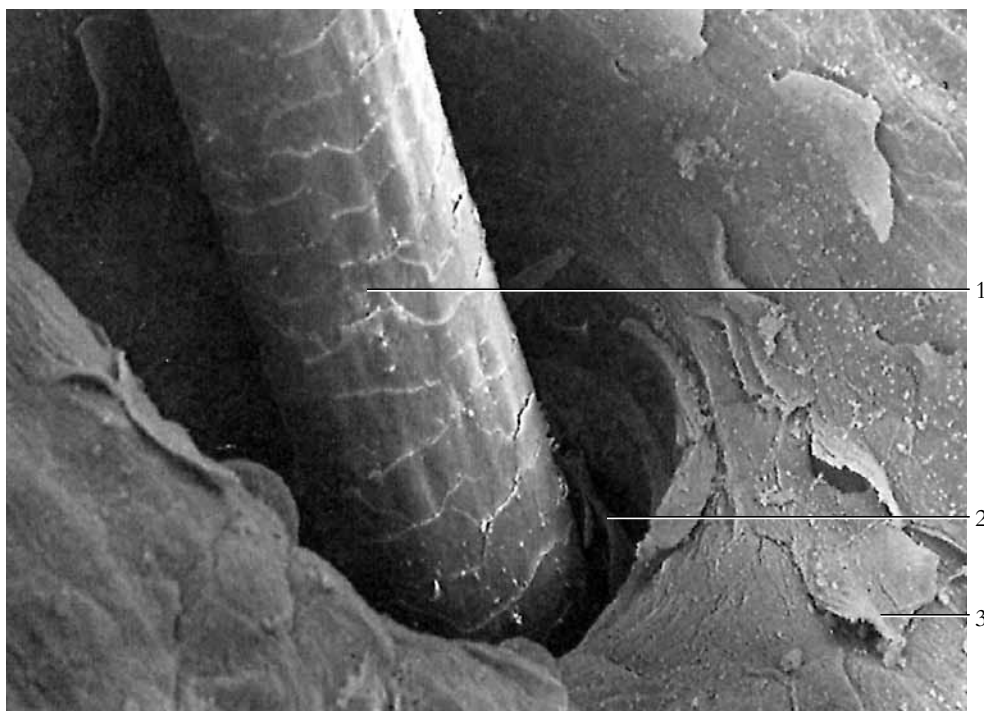
1. Lumen of secretory portion
2. Myoepithelial cell
3. Lumen of excretory portion (or duct)





**Figure 4.10** Hair follicle.

1. Epidermis
2. Sebaceous glands
3. Arrector pili muscle
4. Hair follicle
5. Hair follicle (oblique cut)



**Figure 4.11** An electron micrograph of a hair emerging from a hair follicle.

1. Shaft of hair  
(note the scale-like pattern)
2. Hair follicle
3. Epithelial cell from stratum corneum



# Chapter 5

## Skeletal System: Axial

The skeletal system of an adult human is composed of approximately 206 bones—the number varies from person to person depending on genetic variations. Some adults have extra bones in the skull called **sutural (wormian) bones**. Additional bones may develop in tendons as the tendons move across a joint. Bones formed this way are called **sesamoid bones**, and the patella (kneecap) is an example.

The skeleton is divided into axial and appendicular portions (table 5.1). The **axial skeleton** consists of the bones that form the axis of the body and that support and protect the organs of the head, neck, and trunk. The axial skeleton includes the bones of the skull, auditory ossicles, hyoid bone, vertebral column, and rib cage.

The **appendicular skeleton** (see chapter 6) is composed of the bones of the upper and lower extremities and the bony

girdles, which anchor the appendages to the axial skeleton. The appendicular skeleton includes the bones of the pectoral girdle, upper extremities, pelvic girdle, and lower extremities.

The mechanical functions of the bones of the skeleton include the support and protection of softer body tissues and organs. Also, certain bones function as levers during body movement. The metabolic functions of bones include **hemopoiesis**, or manufacture of blood cells, and mineral storage. Calcium and phosphorus are the two principal minerals stored within bone, and give bone its rigidity and strength.

The bones of the skeleton are classified into four principal types on the basis of shape rather than size. The four classes of bones are **long bones**, **short bones**, **flat bones**, and **irregular bones** (fig. 5.1).

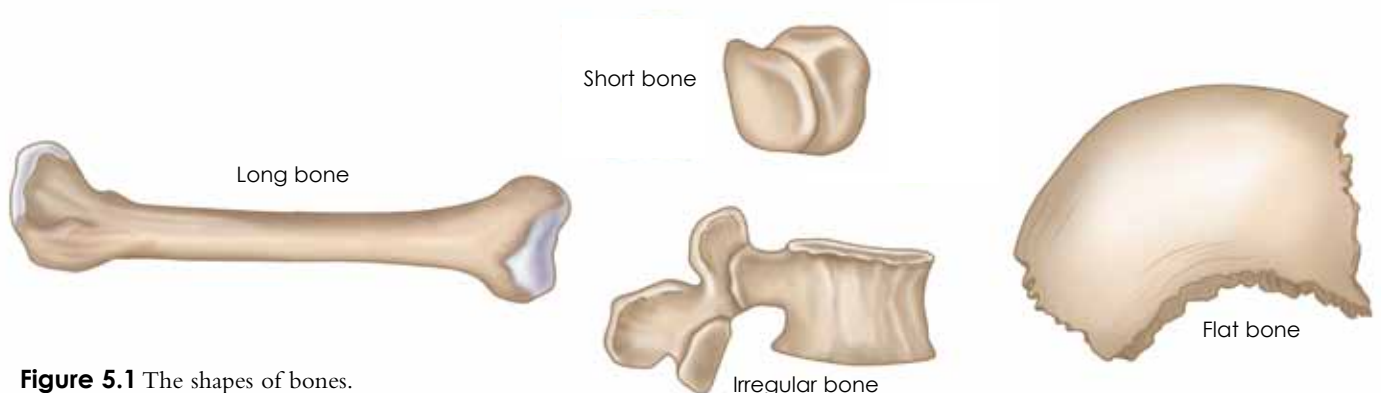
**Table 5.1** Classifications of the bones of the adult skeleton.

### Axial Skeleton

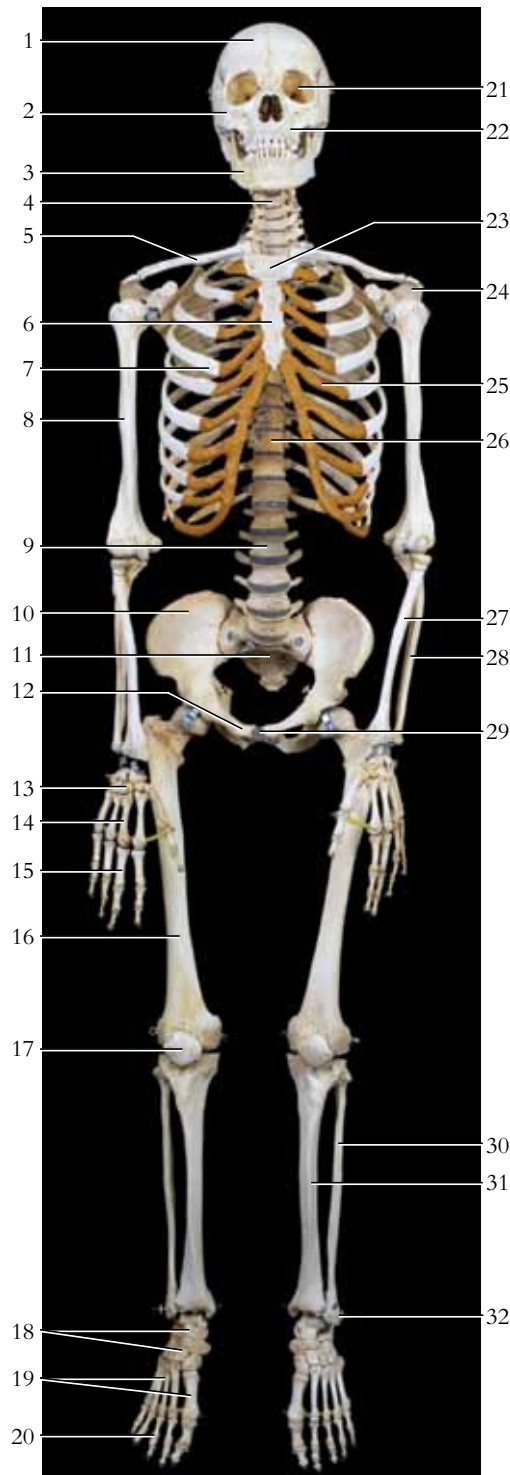
|                                  |   |
|----------------------------------|---|
| <b>Rib cage</b> 25 bones         | 24 ribs 1 sternum   |
| <b>Vertebral column</b> 26 bones | 7 cervical vertebra 12 thoracic vertebra 5 lumbar vertebra 1 sacrum (5 fused bones)<br>1 coccyx (3–5 fused bones)         |
| <b>Skull</b> 22 bones            |   |
| 14 facial bones                  | 2 maxilla 2 palatine bones 2 zygomatic bones 2 lacrimal bones 2 nasal bones<br>1 vomer 2 inferior nasal concha 1 mandible |
| 8 cranial bones                  | 1 frontal bone 2 parietal bones 1 occipital bone 2 temporal bones 1 sphenoid bone<br>1 ethmoid bone                       |
| <b>Auditory ossicles</b> 6 bones | 2 malleus 2 incus 2 stapes  |
| <b>Hyoid</b> 1 bone              | 1 hyoid   |

### Appendicular Skeleton

|                                   |  |
|-----------------------------------|--|
| <b>Pectoral girdle</b> 4 bones    | 2 scapulae 2 clavicles   |
| <b>Pelvic girdle</b> 2 bones      | 2 os coxae (each contains 3 fused bones: ilium, ischium, and pubis)                  |
| <b>Upper extremities</b> 60 bones | 2 humerus 2 radius 2 ulnas 16 carpal bones 10 metacarpal bones 28 phalanx            |
| <b>Lower extremities</b> 60 bones | 2 femurs 2 patellas 2 tibia 2 fibulas 14 tarsal bones 10 metatarsal bones 28 phalanx |

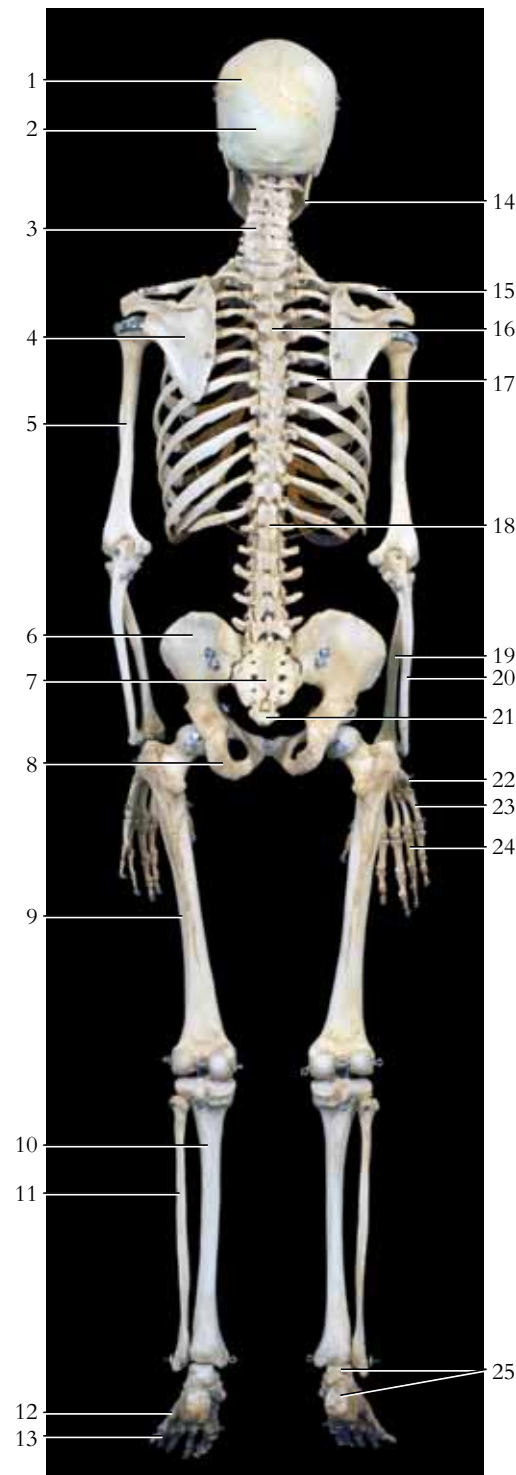


**Figure 5.1** The shapes of bones.



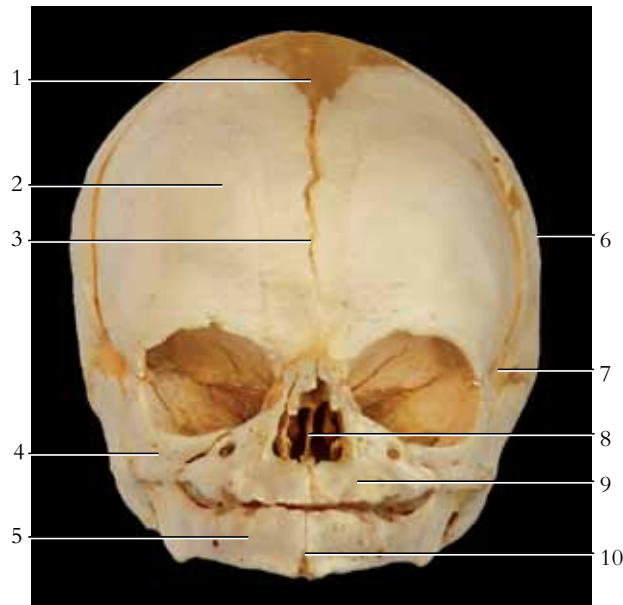
**Figure 5.2** An anterior view of the skeleton.

- |                      |                      |                       |
|----------------------|----------------------|-----------------------|
| 1. Frontal bone      | 12. Pubis            | 23. Manubrium         |
| 2. Zygomatic bone    | 13. Carpal bones     | 24. Scapula           |
| 3. Mandible          | 14. Metacarpal bones | 25. Costal cartilage  |
| 4. Cervical vertebra | 15. Phalanges        | 26. Thoracic vertebra |
| 5. Clavicle          | 16. Femur            | 27. Radius            |
| 6. Body of sternum   | 17. Patella          | 28. Ulna              |
| 7. Rib               | 18. Tarsal bones     | 29. Symphysis pubis   |
| 8. Humerus           | 19. Metatarsal bones | 30. Fibula            |
| 9. Lumbar vertebra   | 20. Phalanges        | 31. Tibia             |
| 10. Ilium            | 21. Orbit            | 32. Lateral malleolus |
| 11. Sacrum           | 22. Maxilla          |                       |



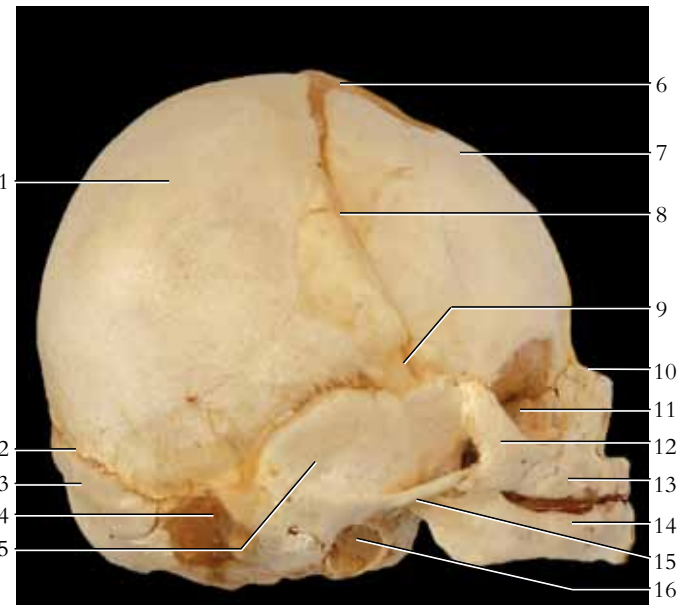
**Figure 5.3** A posterior view of the skeleton.

- |                      |                       |                      |
|----------------------|-----------------------|----------------------|
| 1. Parietal bone     | 10. Tibia             | 18. Lumbar vertebra  |
| 2. Occipital bone    | 11. Fibula            | 19. Radius           |
| 3. Cervical vertebra | 12. Metatarsal bones  | 20. Ulna             |
| 4. Scapula           | 13. Phalanges         | 21. Coccyx           |
| 5. Humerus           | 14. Mandible          | 22. Carpal bones     |
| 6. Ilium             | 15. Clavicle          | 23. Metacarpal bones |
| 7. Sacrum            | 16. Thoracic vertebra | 24. Phalanges        |
| 8. Ischium           | 17. Rib               | 25. Tarsal bones     |
| 9. Femur             |                       |                      |



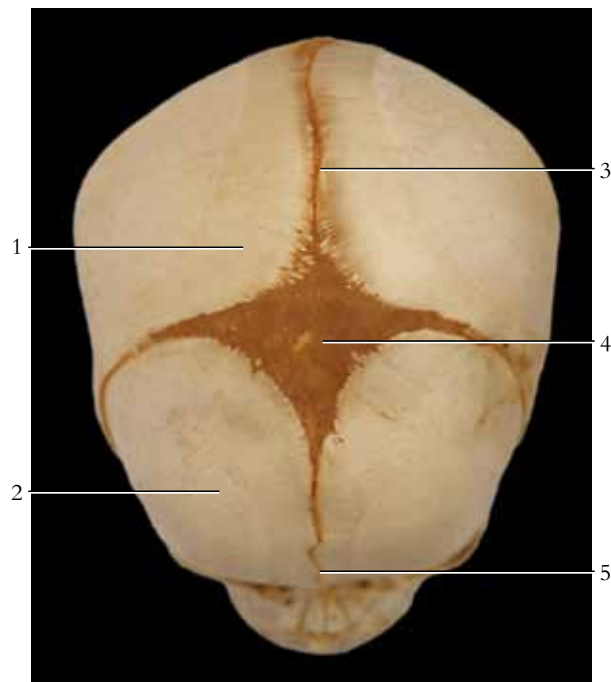
**Figure 5.4** An anterior view of the fetal skull.

- |                      |                           |
|----------------------|---------------------------|
| 1. Anterior fontanel | 6. Parietal bone          |
| 2. Frontal bone      | 7. Anterolateral fontanel |
| 3. Frontal suture    | 8. Nasal septum           |
| 4. Zygomatic bone    | 9. Maxilla                |
| 5. Mandible          | 10. Mental symphysis      |



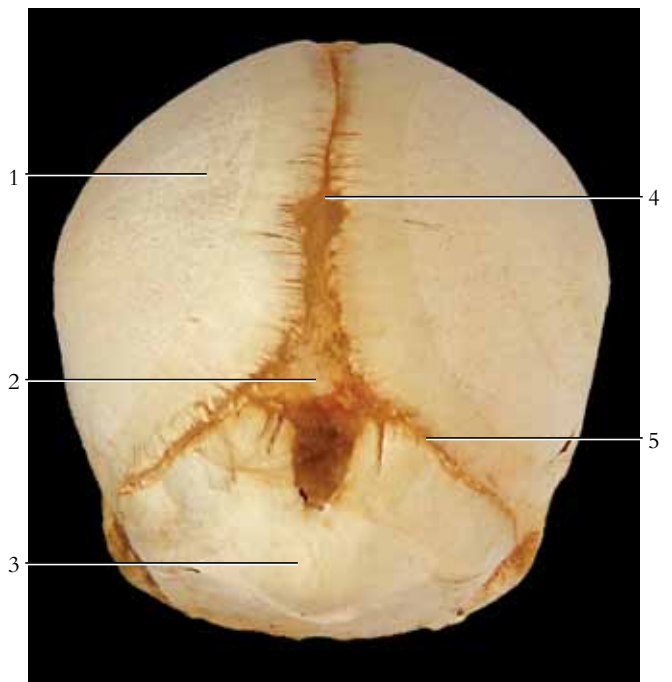
**Figure 5.5** A lateral view of the fetal skull.

- |                              |                              |
|------------------------------|------------------------------|
| 1. Parietal bone             | 9. Anterolateral fontanel    |
| 2. Area of lambdoidal suture | 10. Nasal bone               |
| 3. Occipital bone            | 11. Sphenoid bone            |
| 4. Posterolateral fontanel   | 12. Zygomatic bone           |
| 5. Temporal bone             | 13. Maxilla                  |
| 6. Anterior fontanel         | 14. Mandible                 |
| 7. Frontal bone              | 15. Zygomatic process        |
| 8. Area of coronal suture    | 16. External acoustic meatus |



**Figure 5.6** A superior view of the fetal skull.

- |                            |                      |
|----------------------------|----------------------|
| 1. Parietal bone           | 4. Anterior fontanel |
| 2. Frontal bone            | 5. Synostosis        |
| 3. Area of sagittal suture |                      |



**Figure 5.7** A posterior view of the fetal skull.

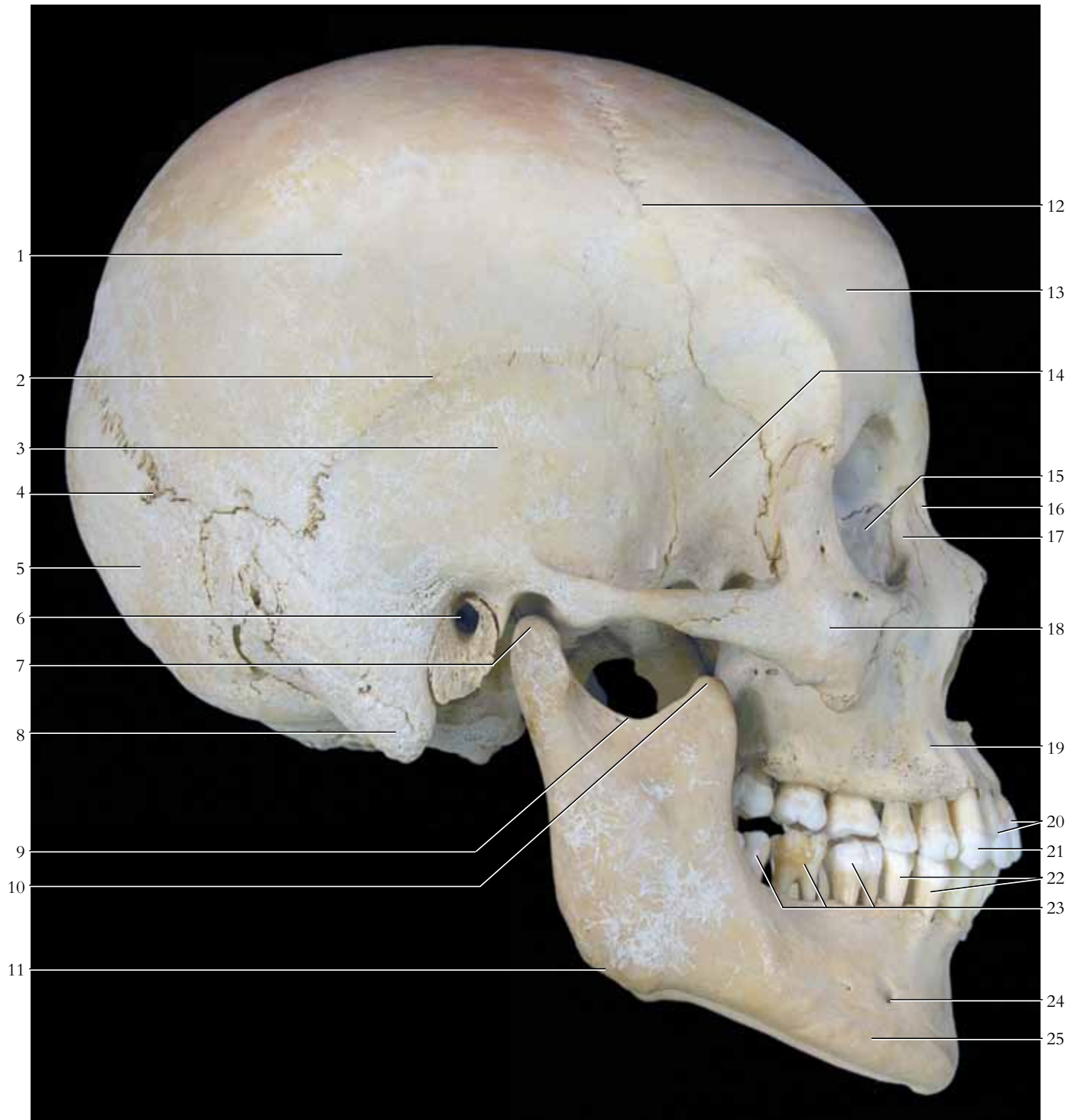
- |                       |                              |
|-----------------------|------------------------------|
| 1. Parietal bone      | 4. Area of sagittal suture   |
| 2. Posterior fontanel | 5. Area of lambdoidal suture |
| 3. Occipital bone     |                              |





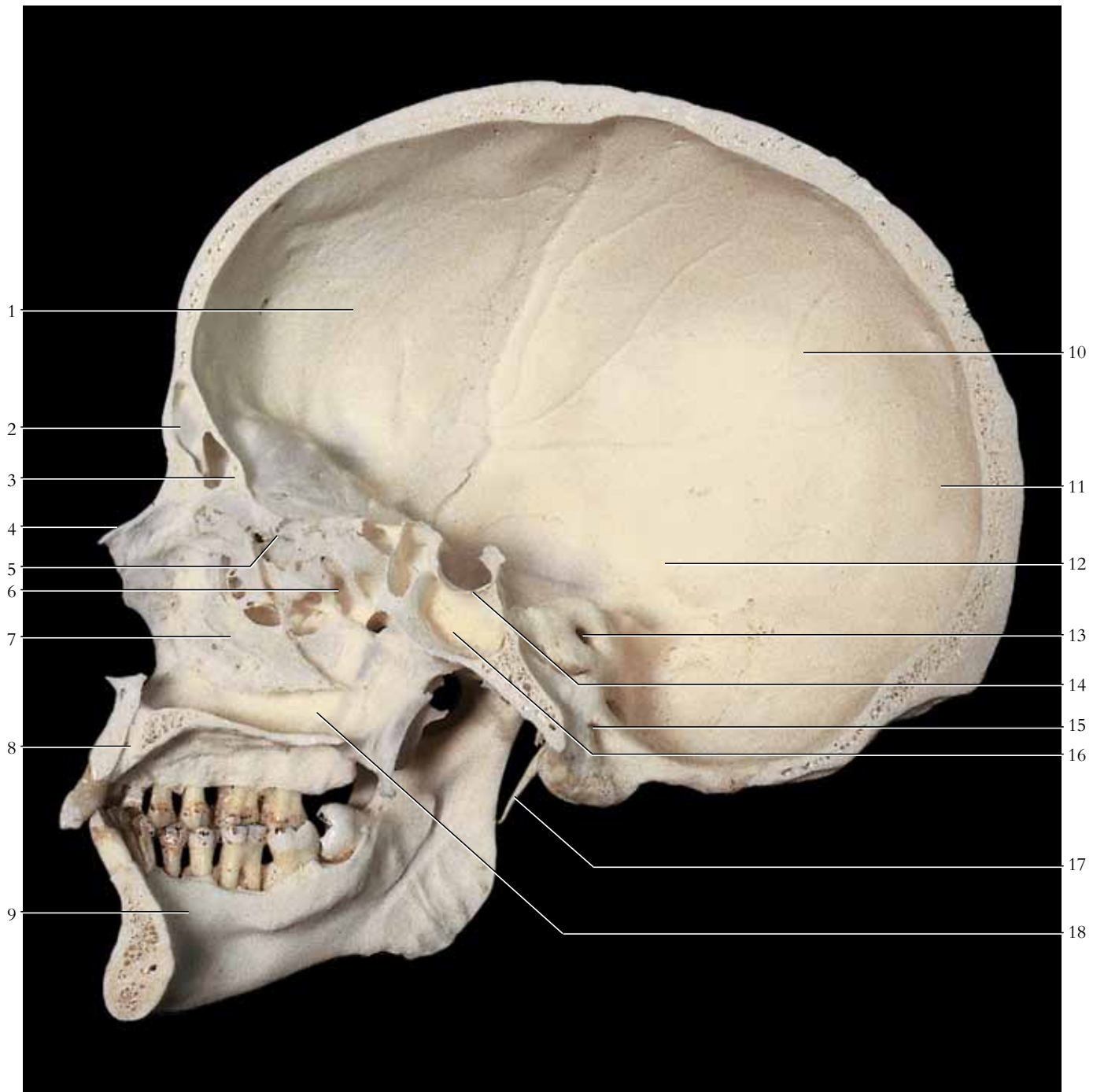
**Figure 5.8** An anterior view of the skull.

- |                                  |   |   |
|----------------------------------|---|---|
| 1. Frontal bone                  | 8. Canine                               | 15. Perpendicular plate of ethmoid bone |
| 2. Supraorbital foramen          | 9. Incisors                             | 16. Infraorbital foramen                |
| 3. Lacrimal bone                 | 10. Mental foramen                      | 17. Inferior nasal concha               |
| 4. Orbital plate of ethmoid bone | 11. Supraorbital margin                 | 18. Maxilla                             |
| 5. Superior orbital fissure      | 12. Nasal bone                          | 19. Mandible                            |
| 6. Zygomatic bone                | 13. Sphenoid bone                       |   |
| 7. Vomer                         | 14. Middle nasal concha of ethmoid bone |   |



**Figure 5.9** A lateral view of the skull.

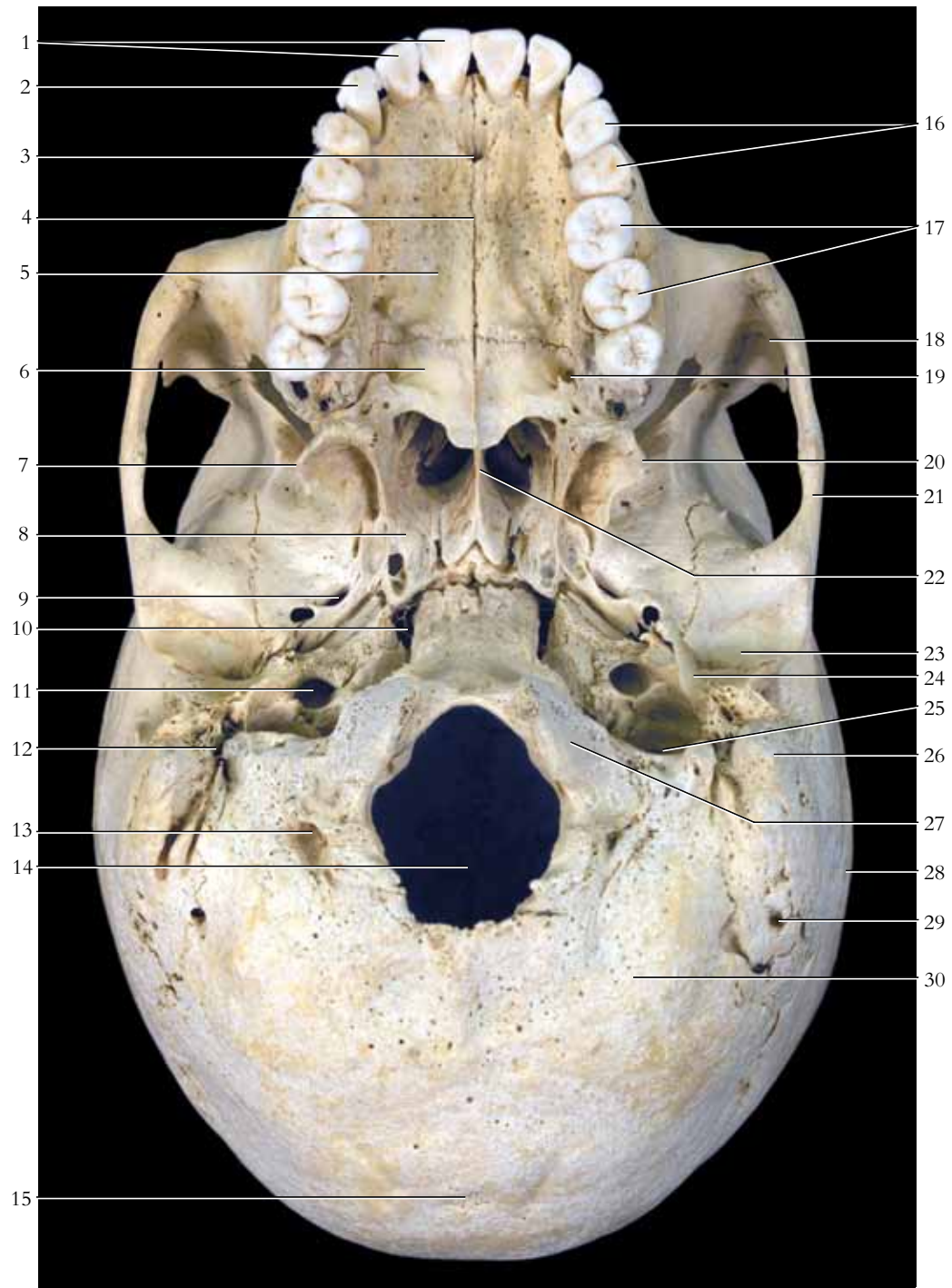
- |                                     |                                   |                    |
|-------------------------------------|-----------------------------------|--------------------|
| 1. Parietal bone                    | 9. Mandibular notch               | 17. Lacrimal bone  |
| 2. Squamosal suture                 | 10. Coronoid process of mandible  | 18. Zygomatic bone |
| 3. Temporal bone                    | 11. Angle of mandible             | 19. Maxilla        |
| 4. Lambdoidal suture                | 12. Coronal suture                | 20. Incisors       |
| 5. Occipital bone                   | 13. Frontal bone                  | 21. Canine         |
| 6. External acoustic meatus         | 14. Sphenoid bone                 | 22. Premolars      |
| 7. Condylar process of mandible     | 15. Orbital plate of ethmoid bone | 23. Molars         |
| 8. Mastoid process of temporal bone | 16. Nasal bone                    | 24. Mental foramen |
|                                     |                                   | 25. Mandible       |



**Figure 5.10** A sagittal view of the skull.

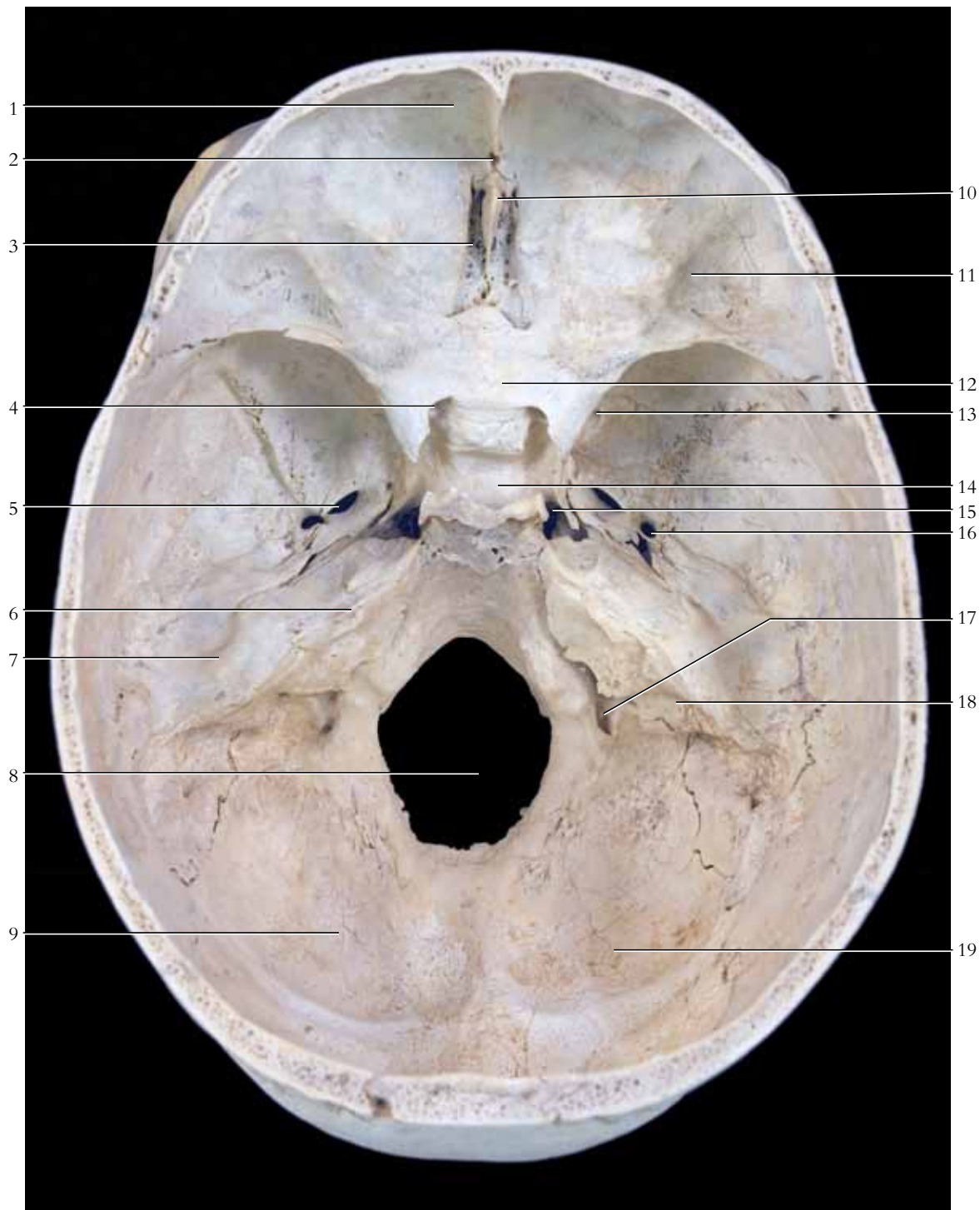
- |                                     |                            |                                      |
|-------------------------------------|----------------------------|--------------------------------------|
| 1. Frontal bone                     | 6. Ethmoidal sinus         | 13. Internal acoustic meatus         |
| 2. Frontal sinus                    | 7. Nasal concha (inferior) | 14. Sella turcica                    |
| 3. Crista galli of ethmoid bone     | 8. Maxilla                 | 15. Hypoglossal canal                |
| 4. Nasal bone                       | 9. Mandible                | 16. Sphenoidal sinus                 |
| 5. Cribriform plate of ethmoid bone | 10. Parietal bone          | 17. Styloid process of temporal bone |
|                                     | 11. Occipital bone         | 18. Vomer                            |
|                                     | 12. Temporal bone          |                                      |





**Figure 5.11** An inferior view of the skull.

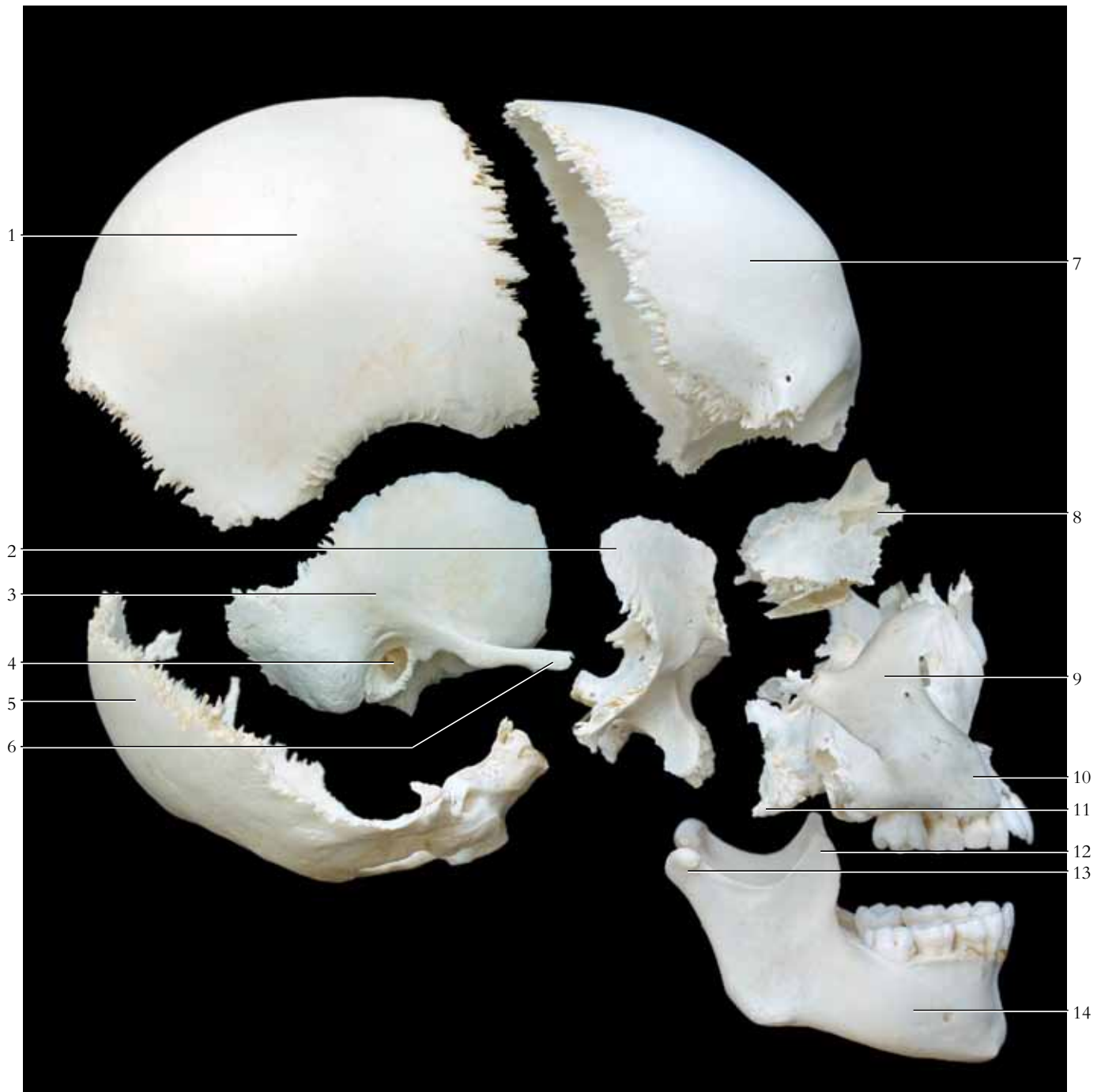
- |   |  |                                      |
|---|--|--------------------------------------|
| 1. Incisors                                   | 12. Stylomastoid foramen                       | 22. Vomer                            |
| 2. Canine                                     | 13. Condylod canal                             | 23. Mandibular fossa                 |
| 3. Incisive foramen                           | 14. Foramen magnum                             | 24. Styloid process of temporal bone |
| 4. Median palatine suture                     | 15. External occipital protuberance            | 25. Jugular foramen                  |
| 5. Maxilla (palatine process)                 | 16. Premolars                                  | 26. Mastoid process of temporal bone |
| 6. Palatine bone                              | 17. Molars                                     | 27. Occipital condyle                |
| 7. Lateral pterygoid process of sphenoid bone | 18. Zygomatic bone                             | 28. Temporal bone                    |
| 8. Sphenoid bone                              | 19. Greater palatine foramen                   | 29. Mastoid foramen                  |
| 9. Foramen ovale                              | 20. Lateral pterygoid process of sphenoid bone | 30. Occipital bone                   |
| 10. Foramen lacerum                           | 21. Zygomatic arch                             |                                      |
| 11. Carotid canal                             |  |                                      |



**Figure 5.12** A superior view of the cranium.

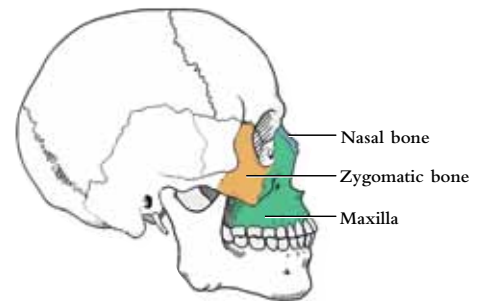
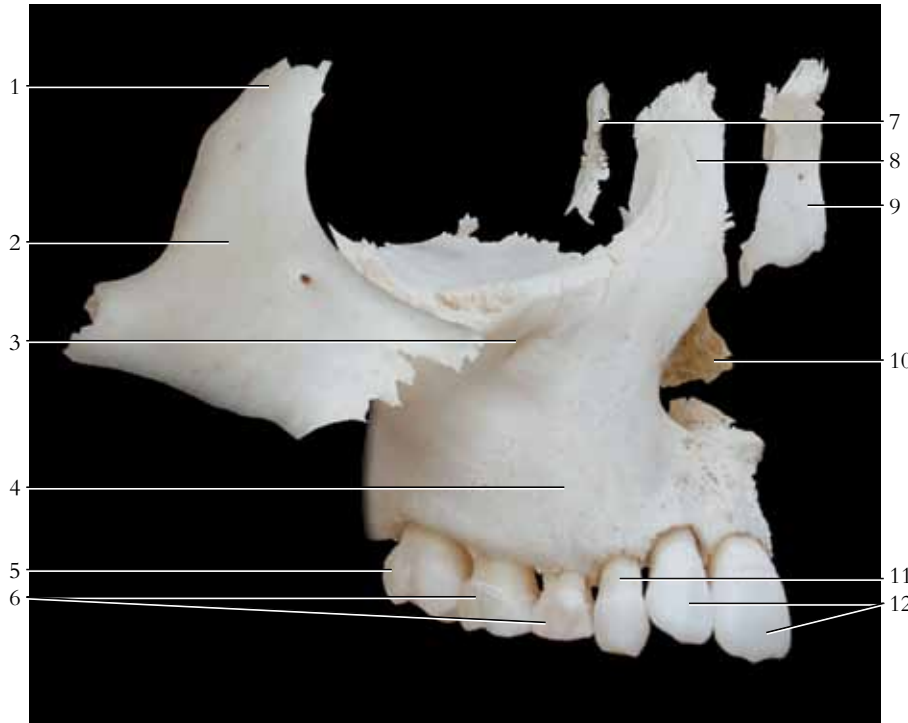
- |                                     |                                  |                                    |
|-------------------------------------|----------------------------------|------------------------------------|
| 1. Frontal bone                     | 7. Temporal bone                 | 14. Sella turcica of sphenoid bone |
| 2. Foramen cecum                    | 8. Foramen magnum                | 15. Foramen lacerum                |
| 3. Cribriform plate of ethmoid bone | 9. Occipital bone                | 16. Foramen spinosum               |
| 4. Optic canal                      | 10. Crista galli of ethmoid bone | 17. Jugular foramen                |
| 5. Foramen ovale                    | 11. Anterior cranial fossa       | 18. Internal acoustic meatus       |
| 6. Petrous part of temporal bone    | 12. Sphenoid bone                | 19. Posterior cranial fossa        |
|                                     | 13. Foramen rotundum             |                                    |





**Figure 5.13** A lateral view of a disarticulated skull.

- |                             |                                       |                                  |
|-----------------------------|---------------------------------------|----------------------------------|
| 1. Parietal bone            | 6. Zygomatic process of temporal bone | 11. Palatine bone                |
| 2. Sphenoid bone            | 7. Frontal bone                       | 12. Coronoid process of mandible |
| 3. Temporal bone            | 8. Ethmoid bone                       | 13. Condylar process of mandible |
| 4. External acoustic meatus | 9. Zygomatic bone                     | 14. Mandible                     |
| 5. Occipital bone           | 10. Maxilla                           |                                  |



**Figure 5.14** The bones of the right facial region.

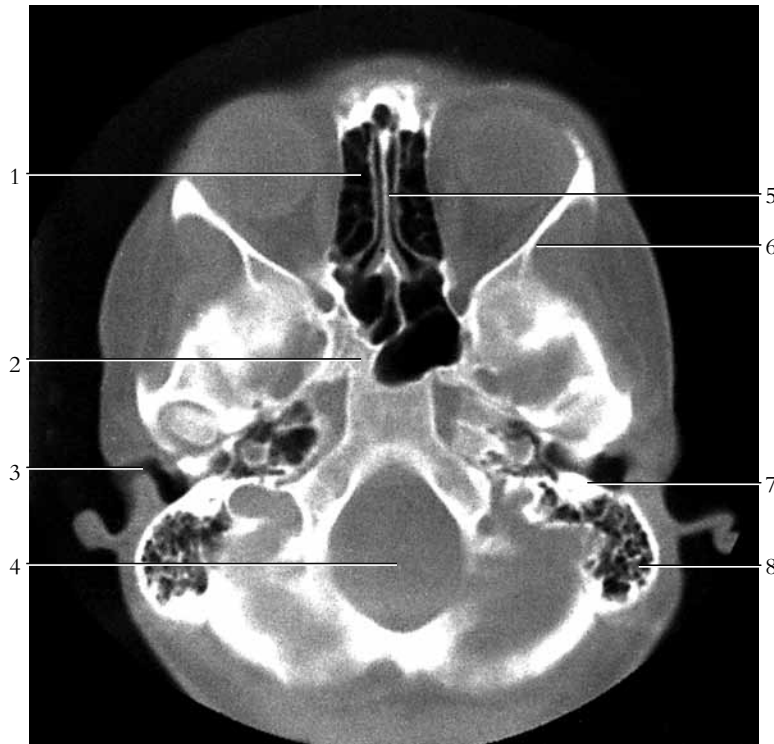
1. Orbital process of zygomatic bone
2. Zygomatic bone
3. Infraorbital foramen
4. Maxilla
5. Molar
6. Premolars
7. Lacrimal bone
8. Frontal process of maxilla
9. Nasal bone
10. Inferior nasal concha
11. Canine
12. Incisors



**Figure 5.15** The orbit of the skull.

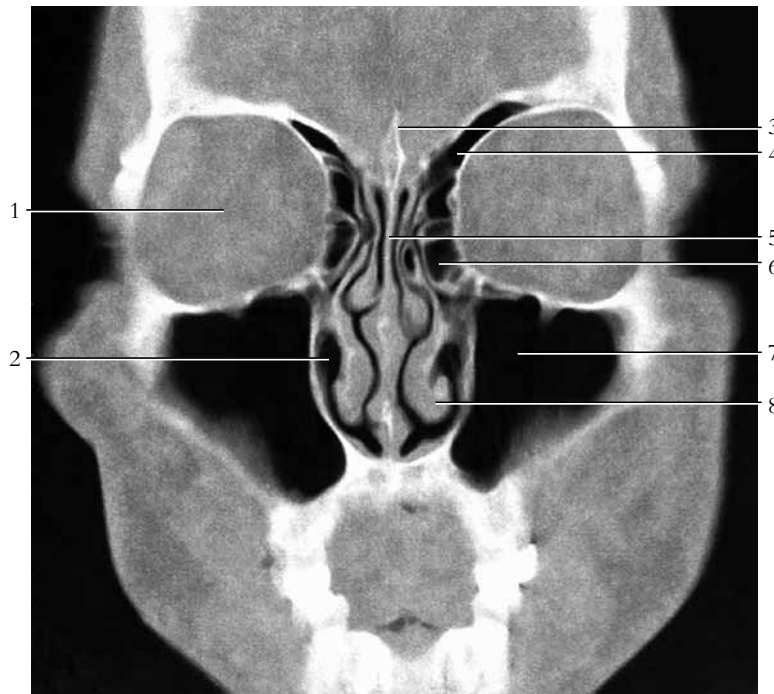
1. Frontal bone
2. Optic foramen
3. Superior orbital fissure
4. Sphenoid bone
5. Lacrimal foramen
6. Temporal bone
7. Inferior orbital fissure
8. Zygomatic bone
9. Nasal bone
10. Ethmoid bone
11. Lacrimal bone
12. Inferior nasal concha
13. Vomer
14. Maxilla





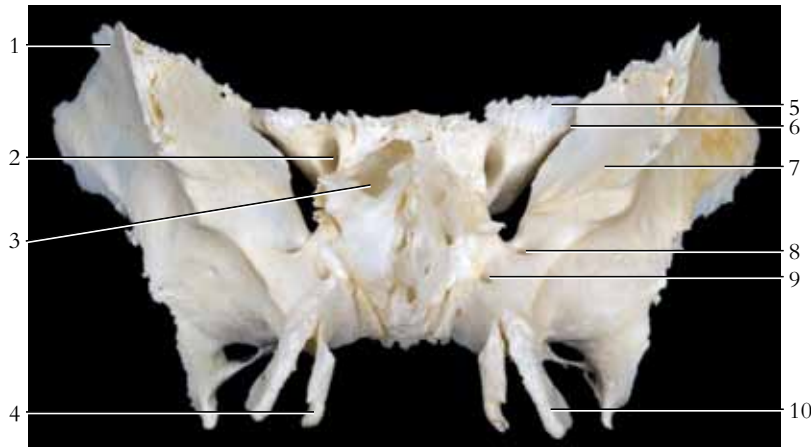
**Figure 5.16** A CT transaxial section through the skull.

1. Nasal cavity
2. Sphenoid bone
3. External acoustic meatus
4. Foramen magnum
5. Nasal septum
6. Wall of bony orbit
7. Middle ear chamber
8. Mastoid sinus



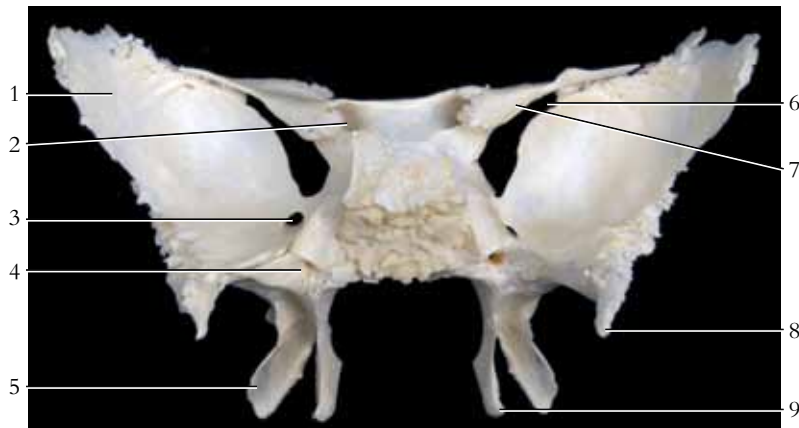
**Figure 5.17** A CT image of the nasal cavity and paranasal sinuses.

1. Eyeball in orbit
2. Nasal cavity
3. Crista galli
4. Frontal sinus
5. Perpendicular plate of ethmoid bone
6. Ethmoidal sinus
7. Maxillary sinus
8. Inferior nasal concha



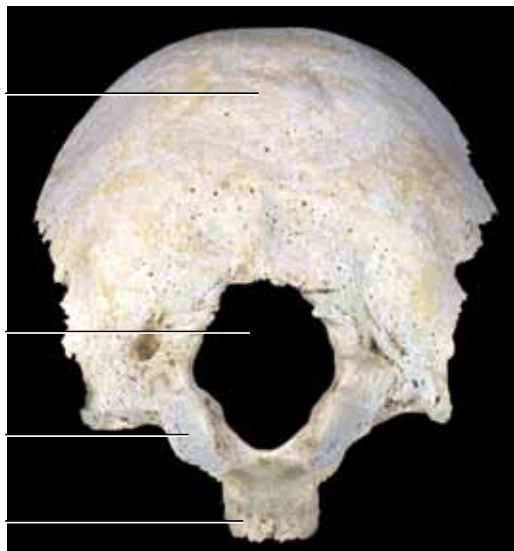
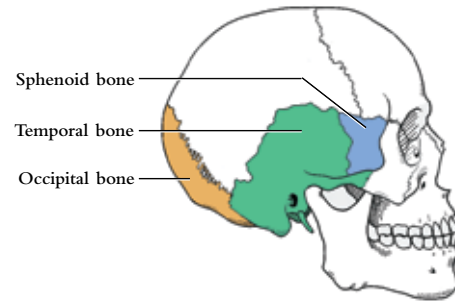
**Figure 5.18** An anterior view of the sphenoid bone.

- |                                  |   |
|----------------------------------|---|
| 1. Greater wing of sphenoid bone | 7. Orbital surface of greater wing of sphenoid bone |
| 2. Optic foramen                 | 8. Foramen rotundum                                 |
| 3. Opening into sphenoidal sinus | 9. Pterygoid canal                                  |
| 4. Medial pterygoid plate        | 10. Lateral pterygoid plate                         |
| 5. Lesser wing of sphenoid bone  |   |
| 6. Superior orbital fissure      |   |



**Figure 5.19** A posterior view of the sphenoid bone.

- |                                  |                                 |
|----------------------------------|---------------------------------|
| 1. Greater wing of sphenoid bone | 7. Lesser wing of sphenoid bone |
| 2. Optic foramen                 | 8. Spine of sphenoid bone       |
| 3. Foramen rotundum              | 9. Medial pterygoid plate       |
| 4. Pterygoid canal               |                                 |
| 5. Lateral pterygoid plate       |                                 |
| 6. Superior orbital fissure      |                                 |



**Figure 5.20** An inferior view of the occipital bone.

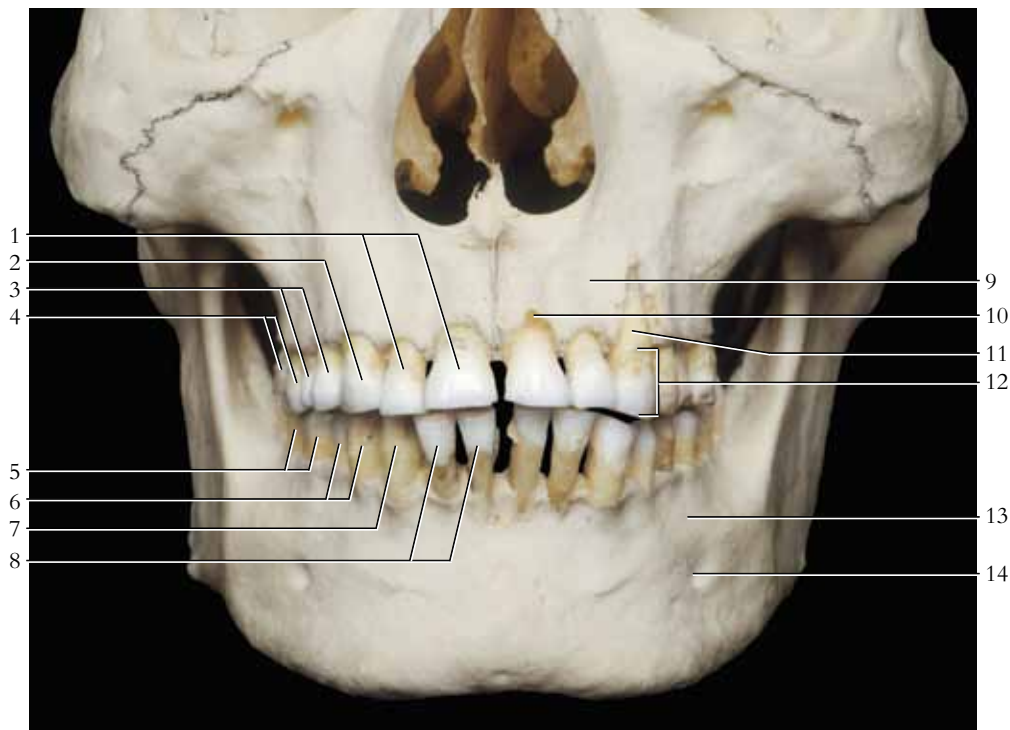
- |                                    |                        |
|------------------------------------|------------------------|
| 1. External occipital protuberance | 3. Occipital condyle   |
| 2. Foramen magnum                  | 4. Pharyngeal tubercle |



**Figure 5.21** A lateral view of the right temporal bone.

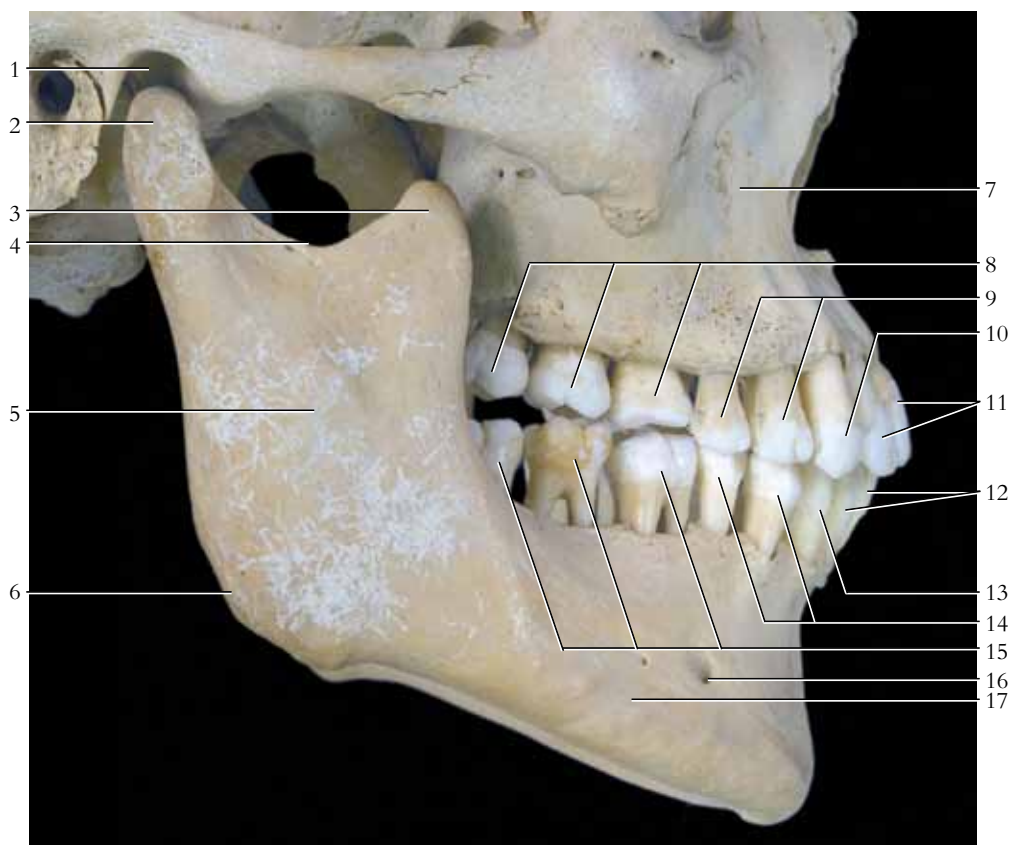
- |                                   |                                       |
|-----------------------------------|---------------------------------------|
| 1. External acoustic meatus       | 5. Zygomatic process of temporal bone |
| 2. Mastoid part of temporal bone  | 6. Mandibular fossa                   |
| 3. Mastoid process                | 7. Tympanic part of temporal bone     |
| 4. Squamous part of temporal bone |                                       |





**Figure 5.22** An anterior view of the jaws and teeth.

1. Superior incisors
2. Superior canine
3. Superior premolars
4. Superior molars
5. Inferior molars
6. Inferior premolars
7. Inferior canine
8. Inferior incisors
9. Maxilla
10. Dental alveolus
11. Root of tooth
12. Crown of tooth
13. Mandible
14. Mental foramen



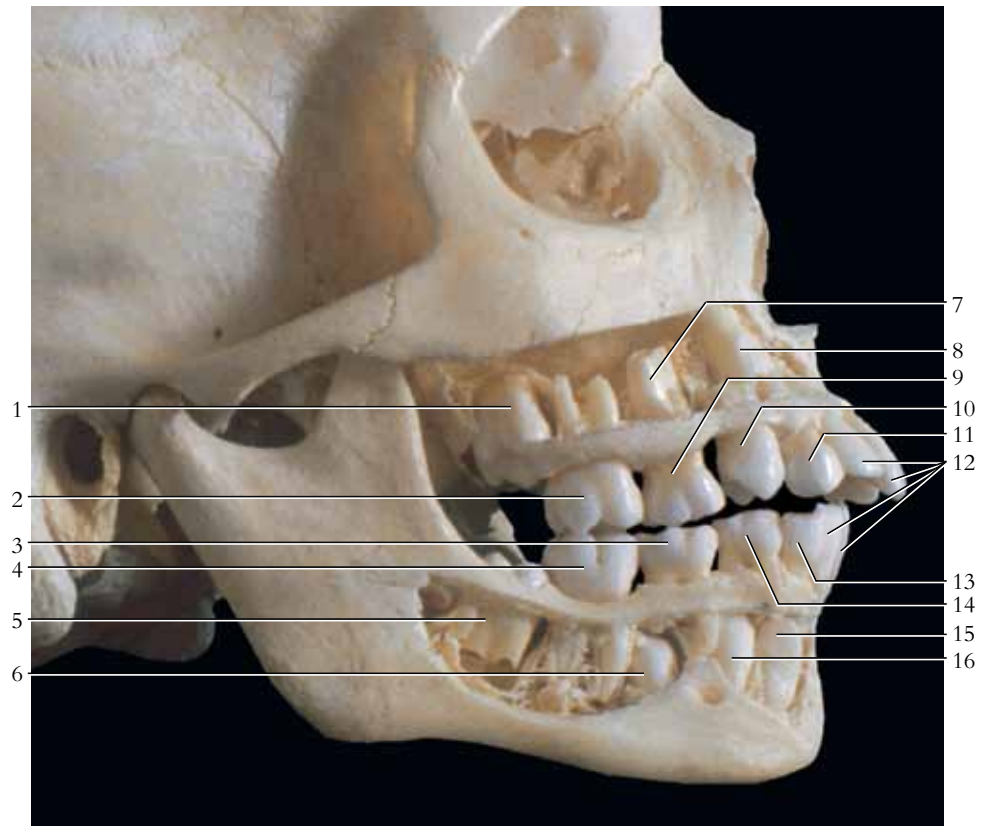
**Figure 5.23** A lateral view of the jaws and teeth.

1. Temporomandibular joint
2. Condylar process of mandible
3. Coronoid process of mandible
4. Mandibular notch
5. Ramus of mandible
6. Angle of mandible
7. Maxilla
8. Superior molars
9. Superior premolars
10. Superior canine
11. Superior incisors
12. Inferior incisors
13. Inferior canine
14. Inferior premolars
15. Inferior molars
16. Mental foramen
17. Body of mandible



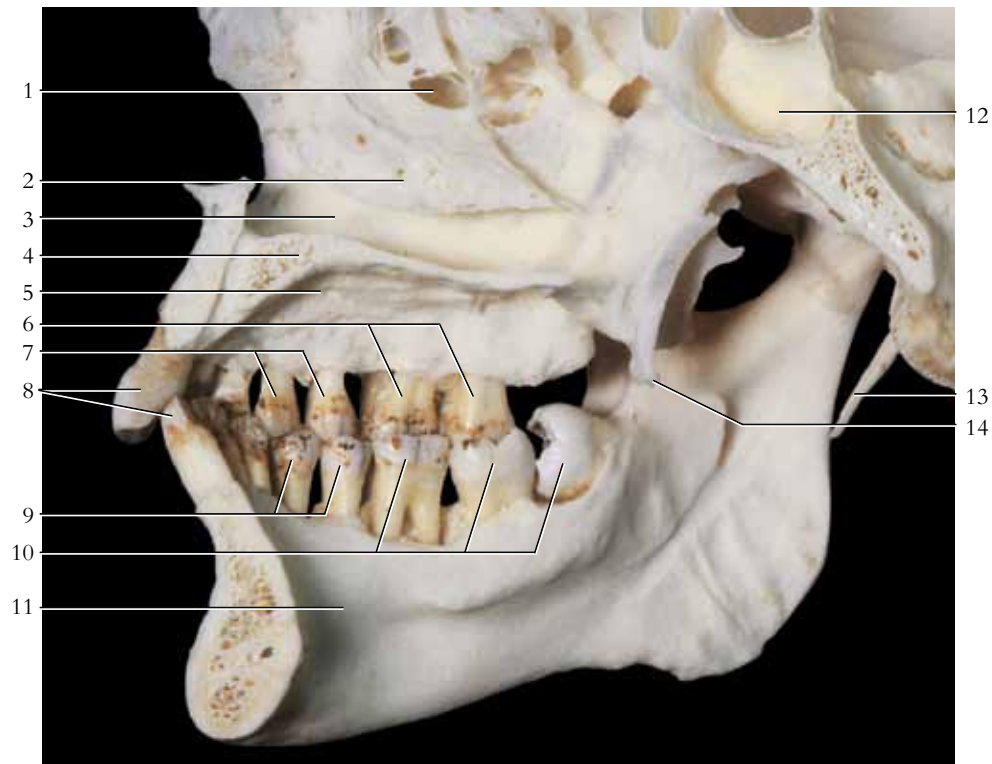
**Figure 5.24** The eruption of teeth seen in a dissected skull of a youth (9 to 12 years old).

1. Permanent second molar
2. Permanent first molar
3. Deciduous second molar
4. Permanent first molar
5. Permanent second molar
6. Permanent second premolar
7. Permanent second premolar
8. Permanent canine
9. Deciduous first molar
10. Permanent first premolar
11. Deciduous canine
12. Incisors
13. Deciduous canine
14. Deciduous first molar
15. Permanent canine
16. Permanent first premolar



**Figure 5.25** A medial view of the jaws and teeth.

1. Ethmoidal sinus
2. Inferior nasal concha
3. Inferior meatus
4. Hard palate
5. Maxilla
6. Superior molars
7. Superior premolars
8. Incisors
9. Inferior premolars
10. Inferior molars (note impacted wisdom tooth)
11. Mandible
12. Sphenoidal sinus
13. Styloid process of temporal bone
14. Medial pterygoid process

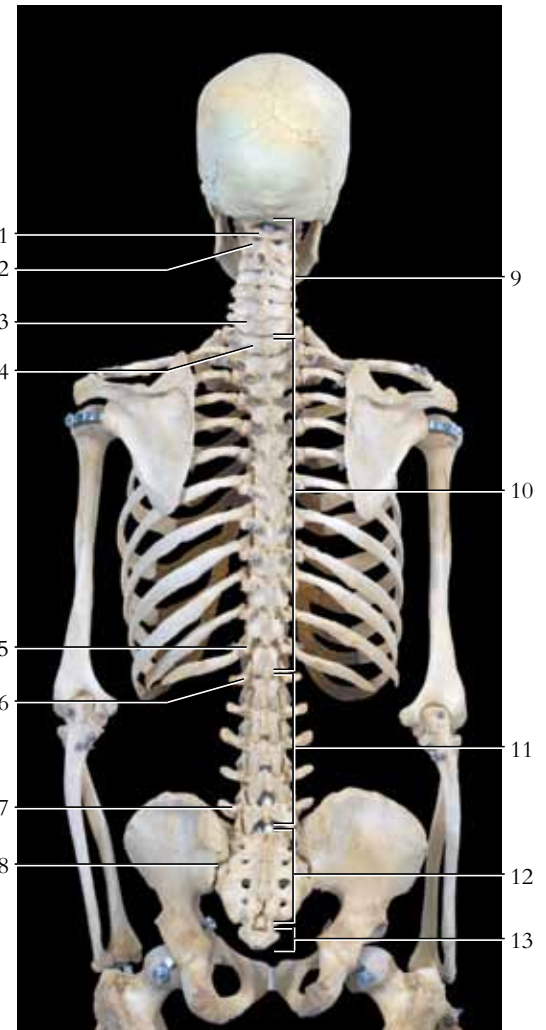






**Figure 5.26** The curvature of the vertebral column.

1. Cervical curvature
2. Thoracic curvature
3. Lumbar curvature
4. Pelvic (sacral) curvature



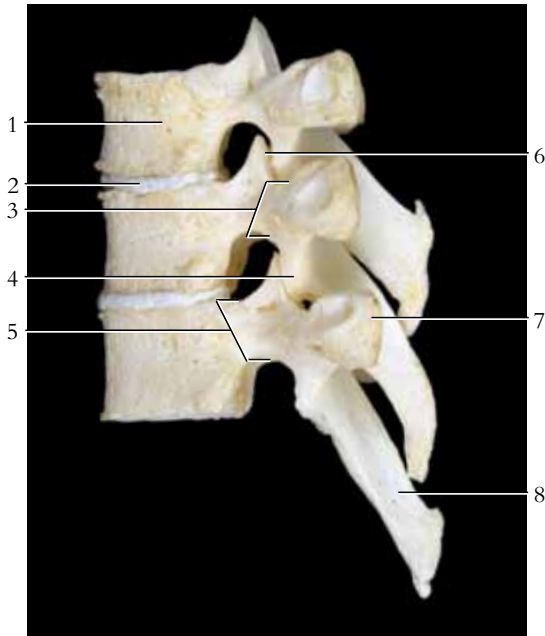
**Figure 5.27** A posterior view of the vertebral column.

1. Atlas
2. Axis
3. Seventh cervical vertebra
4. First thoracic vertebra
5. Twelfth thoracic vertebra
6. First lumbar vertebra
7. Fifth lumbar vertebra
8. Sacroiliac joint
9. Cervical vertebrae
10. Thoracic vertebrae
11. Lumbar vertebrae
12. Sacrum
13. Coccyx



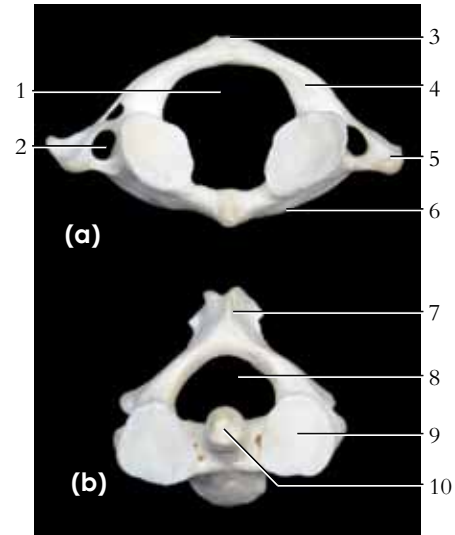
**Figure 5.28** Representative vertebrae.

- |   |                                   |                               |
|---|-----------------------------------|-------------------------------|
| 1. Spinous process (note that it is bifid)    | 4. Body of vertebrae              | 8. Lamina                     |
| 2. Vertebral foramen                          | 5. Facet for tubercle of rib      | 9. Inferior articular surface |
| 3. Transverse foramen (in transverse process) | 6. Inferior facet for head of rib | 10. Transverse process        |
|   | 7. Spinous process                | 11. Pedicle                   |



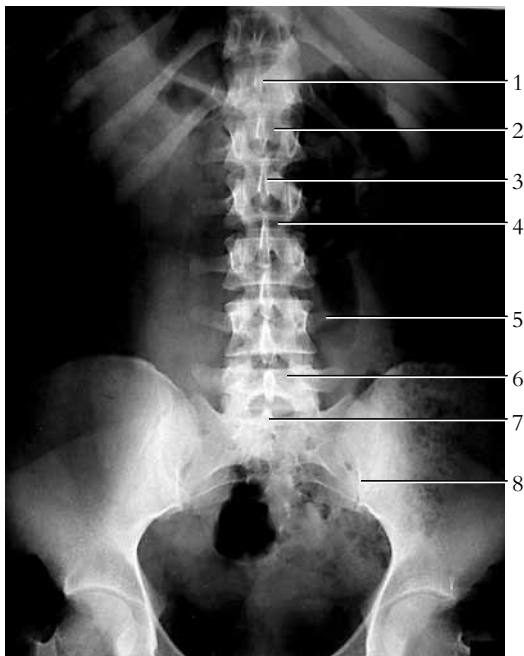
**Figure 5.29** A lateral view of thoracic vertebrae.

- |                               |                             |
|-------------------------------|-----------------------------|
| 1. Vertebral body             | 5. Pedicle                  |
| 2. Intervertebral disc        | 6. Superior articular facet |
| 3. Lamina                     | 7. Transverse process       |
| 4. Inferior articular process | 8. Spinous process          |



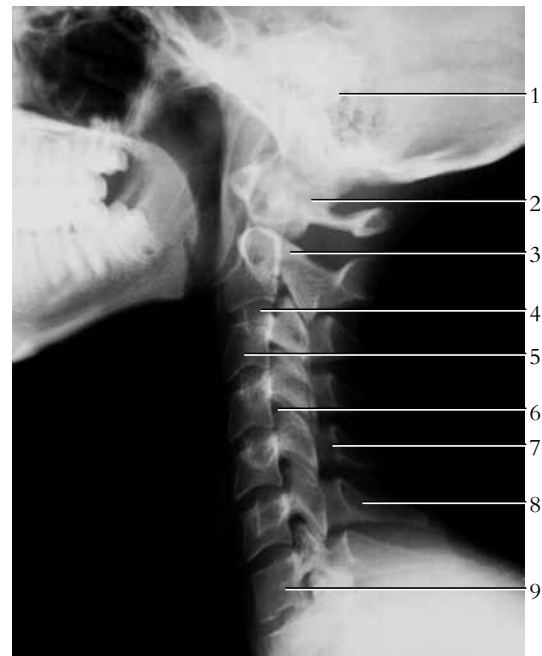
**Figure 5.30** Superior views of (a) the atlas and (b) the axis.

- |  |                                       |
|--|---------------------------------------|
| 1. Vertebral foramen                             | 6. Anterior arch of atlas             |
| 2. Transverse foramen                            | 7. Spinous process of axis            |
| 3. Spinous process of atlas (posterior tubercle) | 8. Vertebral foramen                  |
| 4. Lamina of neural arch                         | 9. Superior articular facet for atlas |
| 5. Transverse process of atlas                   | 10. Dens (odontoid process)           |



**Figure 5.31** A radiograph of the lumbar vertebrae.

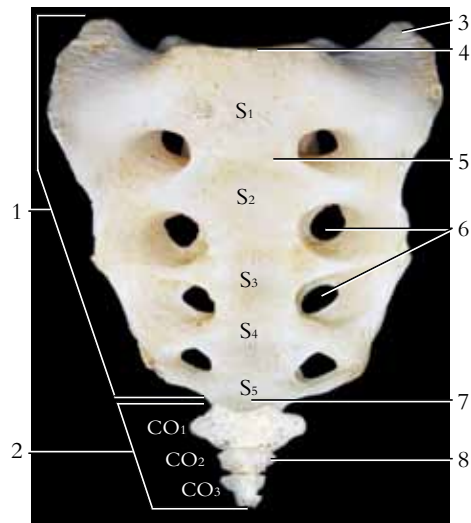
- |                             |                     |
|-----------------------------|---------------------|
| 1. T12                      | 6. Lamina of L5     |
| 2. Body of L1               | 7. Sacrum           |
| 3. Spinous process of L2    | 8. Sacroiliac joint |
| 4. Intervertebral disc      |                     |
| 5. Transverse process of L4 |                     |



**Figure 5.32** A radiograph of the cervical vertebrae.

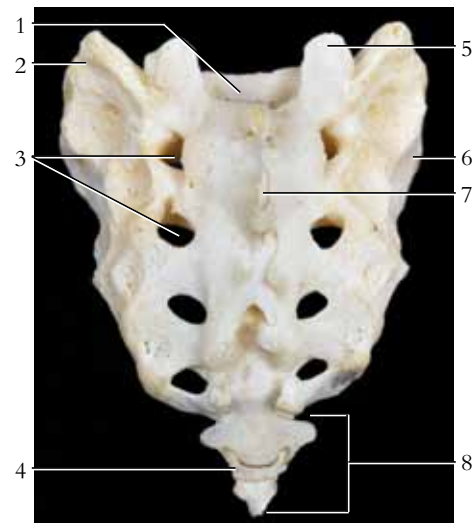
- |                                     |                           |
|-------------------------------------|---------------------------|
| 1. Petrous portion of temporal bone | 5. Body of C3             |
| 2. Atlas                            | 6. Intervertebral foramen |
| 3. Axis                             | 7. Spinous process of C5  |
| 4. Intervertebral disc              | 8. Spinous process of C6  |
|                                     | 9. Body of C7             |





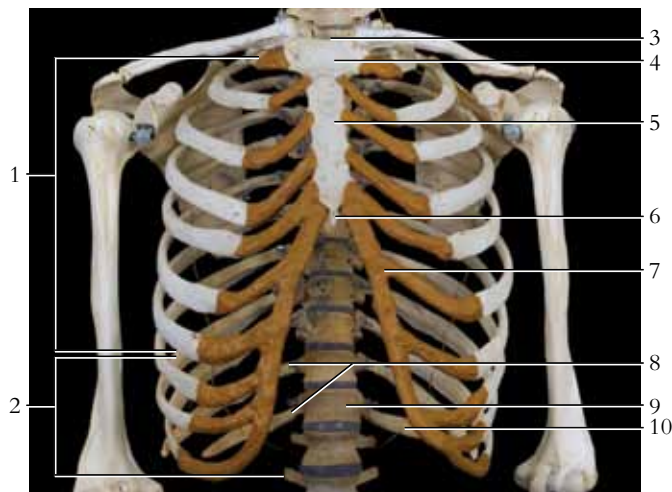
**Figure 5.33** An anterior view of the sacrum and coccyx.

- |                    |                             |
|--------------------|-----------------------------|
| 1. Sacrum          | 6. Anterior sacral foramina |
| 2. Coccyx          | 7. Apex of sacrum           |
| 3. Sacral ala      | 8. Coccygeal cornu          |
| 4. Base of sacrum  |                             |
| 5. Transverse line |                             |



**Figure 5.34** A posterior view of the sacrum and coccyx.

- |                                     |                               |
|-------------------------------------|-------------------------------|
| 1. Superior portion of sacral canal | 5. Superior articular process |
| 2. Sacral ala                       | 6. Auricular surface          |
| 3. Posterior sacral foramina        | 7. Median sacral crest        |
| 4. Coccygeal cornu                  | 8. Coccyx                     |



**Figure 5.35** An anterior view of the rib cage.

- |                            |   |
|----------------------------|---|
| 1. True ribs (seven pairs) | 7. Costal cartilage                                 |
| 2. False ribs (five pairs) | 8. Floating ribs (inferior two pairs of false ribs) |
| 3. Jugular notch           | 9. Twelfth thoracic vertebra                        |
| 4. Manubrium               | 10. Twelfth rib                                     |
| 5. Body of sternum         |   |
| 6. Xiphoid process         |   |



**Figure 5.36** A posterior view of the rib cage.

- |  |                    |
|--|--------------------|
| 1. Intercostal spaces                      | 3. Tubercle of rib |
| 2. Transverse process of thoracic vertebra | 4. Angle of rib    |
|  | 5. Body of rib     |



**Figure 5.37** A rib.

- |   |
|---|
| 1. Superior border                        |
| 2. Body of rib                            |
| 3. Articulation site for costal cartilage |
| 4. Internal surface                       |
| 5. Costal groove                          |
| 6. Angle of rib                           |
| 7. Neck of rib                            |
| 8. Articular surface                      |
| 9. Head of rib                            |

# Chapter 6

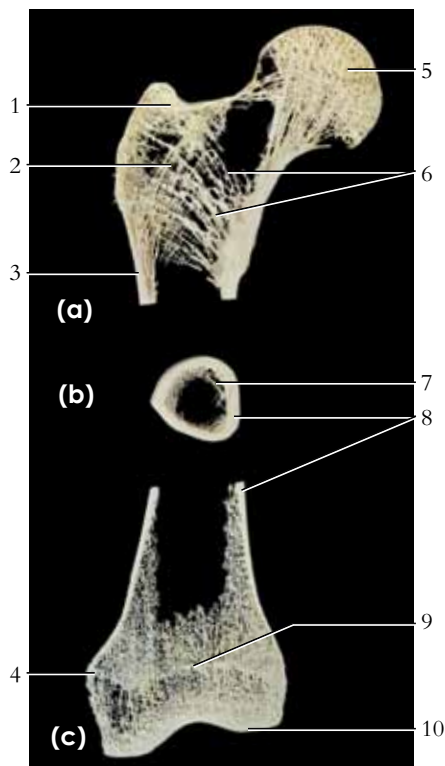
## Skeletal System: Appendicular

The structure of the **pectoral girdle** and **upper extremities** of the appendicular skeleton is adaptive for freedom of movement and extensive muscle attachment. The structure of the **pelvic girdle** and **lower extremities** is adaptive for support and locomotion.

The pectoral girdle is composed of two **scapulae** and two **clavicles**. The clavicles attach the pectoral girdle to the axial skeleton at the **sternum**. The bones of each upper extremity are the **humerus**, **ulna**, **radius**, eight **carpal bones**, five **metacarpal bones**, and fourteen **phalanges**. In addition, two or more **sesamoid bones** at the interphalangeal joints are usually present.

The pelvic girdle, or **pelvis**, is formed by two **os coxae** (hip bones) which are united anteriorly by the **symphysis pubis**. The pelvic girdle is attached posteriorly to the sacrum of the vertebral column. Each **os coxae** consists of three separate bones: the **ilium**, the **ischium**, and the **pubis**. These bones are fused in an adult. The bones of each lower extremity are the **femur**, **patella**, **tibia**, **fibula**, seven **tarsal bones**, five **metatarsal bones**, and fourteen **phalanges**. In addition, two or more **sesamoid bones** at the interphalangeal joints are usually present.

The various surface features used to identify specific bones are presented in Table 6.1.

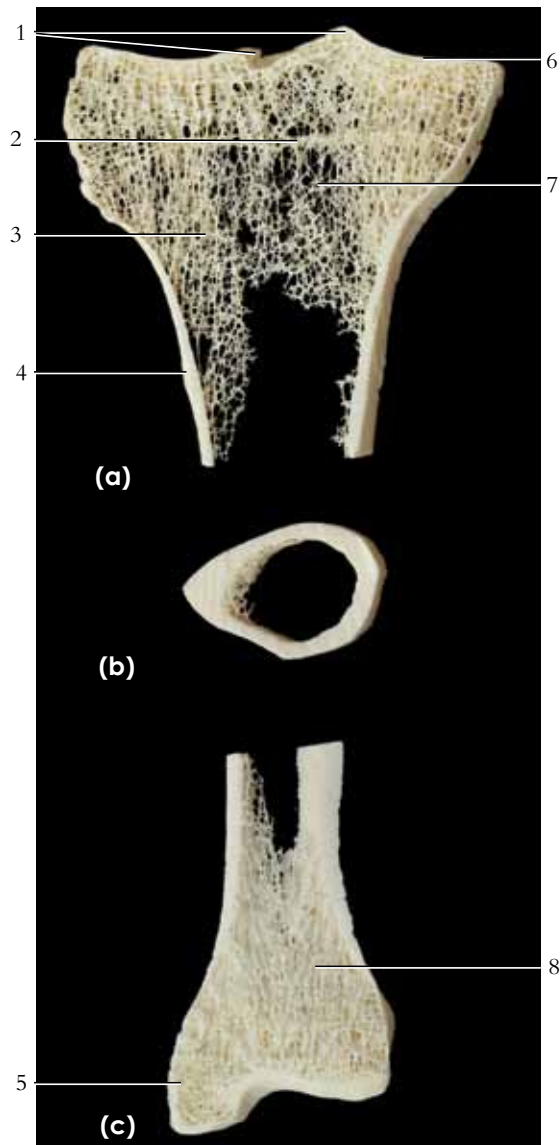


**Figure 6.1** The sections of a human femur showing the outer compact bone and inner spongy bone. Note the trajectorial (stress) lines of the trabeculae of spongy bone.  
(a) A coronal section of the proximal end of the femur  
(b) A cross section of the body of the femur  
(c) A coronal section of the distal end of the femur  
1. Greater trochanter  
2. Spongy bone  
3. Compact bone  
4. Femoral epicondyle  
5. Head of femur  
6. Trabeculae of spongy bone  
7. Spongy bone surrounding medullary cavity  
8. Compact bone  
9. Epiphyseal line (remnant of epiphyseal plate)  
10. Condyle of femur

**Table 6.1** Surface features used to identify specific regions of bones.

| Articulating surfaces              | Description  | Example       |
|------------------------------------|--|---------------|
| Condyle                            | A large, rounded, articulating knob                    | Mandible      |
| Facet                              | A flattened or shallow articulating surface            | Vertebra      |
| Head                               | A prominent, rounded, articulating end of a bone       | Femur         |
| <b>Nonarticulating prominences</b> |  |               |
| Crest                              | A narrow, ridgelike projection                         | Ilium         |
| Epicondyle                         | A projection above a condyle                           | Humerus       |
| Process                            | Any marked bony prominence                             | Radius        |
| Spine                              | A sharp, slender process                               | Scapula       |
| Trochanter                         | A large process found only on the femur                | Femur         |
| Tubercle                           | A small rounded process                                | Humerus       |
| Tuberosity                         | A large roughened process                              | Tibia         |
| <b>Depressions and openings</b>    |  |               |
| Alveolus                           | A deep pit or socket                                   | Maxilla       |
| Fissure                            | A narrow, slitlike opening                             | Sphenoid      |
| Foramen (plural, foramina)         | A rounded opening through a bone                       | Sphenoid      |
| Fossa                              | A flattened or shallow surface                         | Scapula       |
| Fovea                              | A small pit or depression; may or may not be articular | Femur         |
| Meatus, or canal                   | A tubelike passageway through a bone                   | Temporal bone |
| Sinus                              | A cavity or hollow space in a bone                     | Maxilla       |
| Sulcus                             | A groove in a bone                                     | Humerus       |





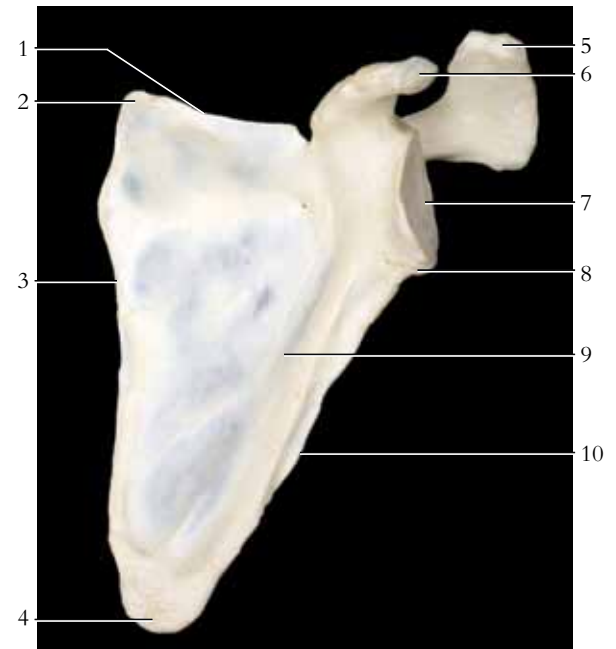
**Figure 6.2** The sections of a human tibia showing the outer compact bone and the inner spongy bone. Note the trajectorial (stress) lines of the trabeculae of spongy bone.

- (a) A coronal section of the proximal end of the tibia  
 (b) A cross section of the body of tibia  
 (c) A coronal section of the distal end of the tibia
- |                            |                              |
|----------------------------|------------------------------|
| 1. Intercondylar eminences | 6. Lateral condyle           |
| 2. Epiphyseal line         | 7. Trabeculae of spongy bone |
| 3. Spongy bone             | 8. Spongy bone               |
| 4. Compact bone            |                              |
| 5. Medial malleolus        |                              |



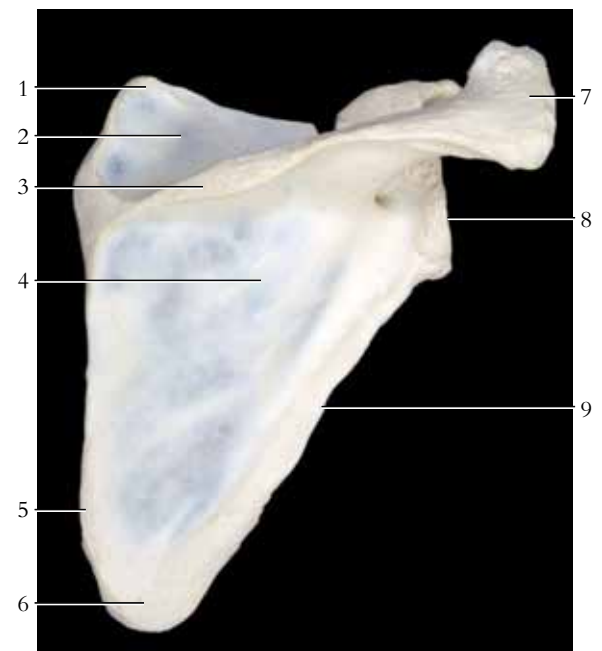
**Figure 6.5** An inferior view of the clavicle.

- |                       |                      |
|-----------------------|----------------------|
| 1. Conoid tubercle    | 3. Sternal extremity |
| 2. Acromial extremity |                      |



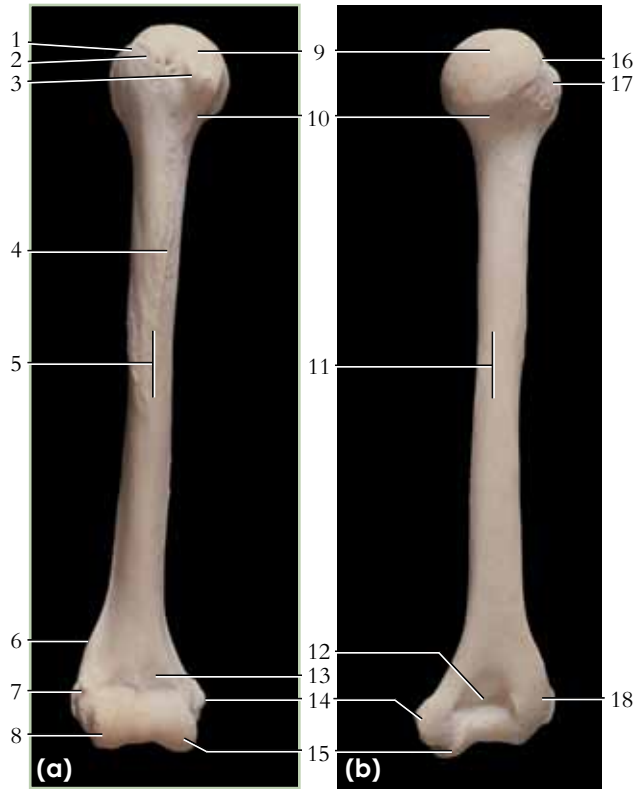
**Figure 6.3** An anterior view of the left scapula.

- |                              |                               |
|------------------------------|-------------------------------|
| 1. Superior border           | 6. Coracoid process           |
| 2. Superior angle            | 7. Glenoid fossa              |
| 3. Medial (vertebral) border | 8. Infraglenoid tubercle      |
| 4. Inferior angle            | 9. Subscapular fossa          |
| 5. Acromion                  | 10. Lateral (axillary) border |



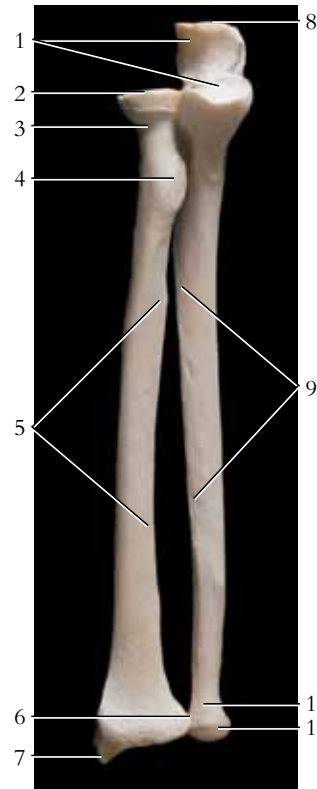
**Figure 6.4** A posterior view of the right scapula.

- |                              |                              |
|------------------------------|------------------------------|
| 1. Superior angle            | 6. Inferior angle            |
| 2. Supraspinous fossa        | 7. Acromion                  |
| 3. Spine                     | 8. Glenoid fossa             |
| 4. Infraspinous fossa        | 9. Lateral (axillary) border |
| 5. Medial (vertebral) border |                              |



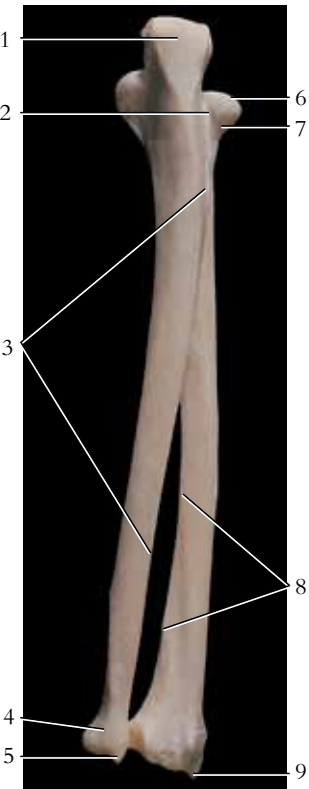
**Figure 6.6** The right humerus. (a) Anterior view  
(b) Posterior view.

- |                                     |                                       |
|-------------------------------------|---------------------------------------|
| 1. Greater tubercle                 | 10. Surgical neck                     |
| 2. Intertubercular groove           | 11. Posterior body (shaft) of humerus |
| 3. Lesser tubercle                  | 12. Olecranon fossa                   |
| 4. Deltoid tuberosity               | 13. Coronoid fossa                    |
| 5. Anterior body (shaft) of humerus | 14. Medial epicondyle                 |
| 6. Lateral supracondylar ridge      | 15. Trochlea                          |
| 7. Lateral epicondyle               | 16. Anatomical neck                   |
| 8. Capitulum                        | 17. Greater tubercle                  |
| 9. Head of humerus                  | 18. Lateral epicondyle                |



**Figure 6.7** An anterior view of the right ulna and radius.

- |                              |                        |
|------------------------------|------------------------|
| 1. Trochlear notch           | 8. Olecranon           |
| 2. Head of radius            | 9. Interosseous margin |
| 3. Neck of radius            | 10. Neck of ulna       |
| 4. Radial tuberosity         | 11. Head of ulna       |
| 5. Interosseous margin       |                        |
| 6. Ulnar notch of radius     |                        |
| 7. Styloid process of radius |                        |



**Figure 6.8** A posterior view of the right ulna and radius.

- |                              |
|------------------------------|
| 1. Olecranon                 |
| 2. Radial notch of ulna      |
| 3. Interosseous margin       |
| 4. Head of ulna              |
| 5. Styloid process of ulna   |
| 6. Head of radius            |
| 7. Neck of radius            |
| 8. Interosseous margin       |
| 9. Styloid process of radius |



**Figure 6.9** A radiograph of the left elbow region, posterior view.

- |                                  |                                  |
|----------------------------------|----------------------------------|
| 1. Humerus                       | 10. Medial epicondyle of humerus |
| 2. Olecranon fossa of humerus    | 11. Olecranon                    |
| 3. Lateral epicondyle of humerus | 12. Trochlea                     |
| 4. Capitulum                     | 13. Radial notch of ulna         |
| 5. Articular surface of radius   | 14. Tuberosity of ulna           |
| 6. Head of radius                | 15. Ulna                         |
| 7. Neck of radius                |                                  |
| 8. Radial tuberosity             |                                  |
| 9. Radius                        |                                  |

**Figure 6.10** A radiograph showing fractures of the ulna and radius of a ten-year-old child. Notice the distal epiphyseal plates of the ulna and the radius.

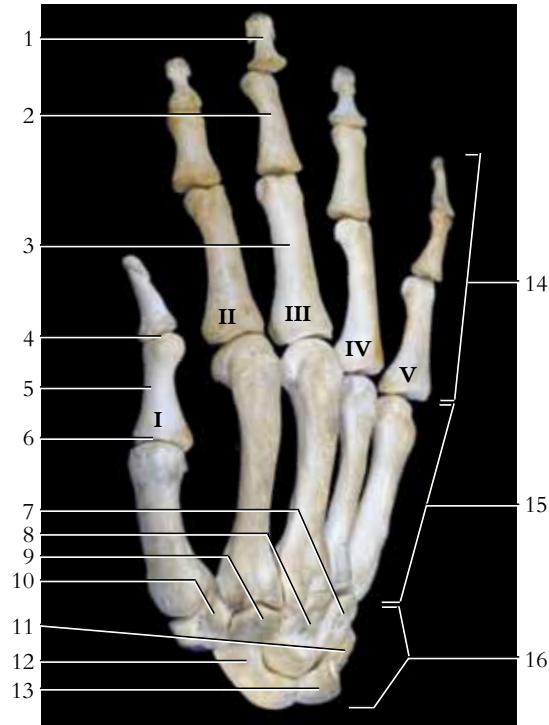
- |           |
|-----------|
| 1. Ulna   |
| 2. Radius |





**Figure 6.11** A radiograph showing a fracture of the distal portion of the left radius and medial displacement of the antebrachium.

1. Ulna
2. Radius
3. Site of fracture
4. Styloid process of radius
5. Carpal bones
6. First metacarpal bone



**Figure 6.12** A posterior view of the right wrist and hand.

- |                                    |                                    |
|------------------------------------|------------------------------------|
| 1. Distal phalanx of third digit   | 9. Trapezoid bone                  |
| 2. Middle phalanx of third digit   | 10. Trapezium bone                 |
| 3. Proximal phalanx of third digit | 11. Triquetrum bone                |
| 4. Head of phalanx                 | 12. Scaphoid bone                  |
| 5. Body of phalanx                 | 13. Lunate bone                    |
| 6. Base of phalanx                 | 14. Phalanges of fifth digit       |
| 7. Hamate bone                     | 15. Metacarpal bones (first–fifth) |
| 8. Capitate bone                   | 16. Carpal bones                   |



**Figure 6.13** A radiograph of the right wrist and hand, posterior view.

1. Phalanges of fifth digit
2. Fifth metacarpal bone
3. Hamate bone
4. Capitate bone
5. Triquetrum and pisiform bones
6. Styloid process of ulna
7. Distal radioulnar joint
8. Ulna
9. Distal phalanx of third digit
10. Middle phalanx of third digit
11. Proximal phalanx of third digit
12. Distal phalanx of pollex (thumb)
13. Proximal phalanx of pollex (thumb)
14. Sesamoid bone
15. First metacarpal bone
16. Trapezoid bone
17. Trapezium bone
18. Scaphoid bone
19. Capitate bone
20. Lunate bone
21. Styloid process of radius
22. Radius



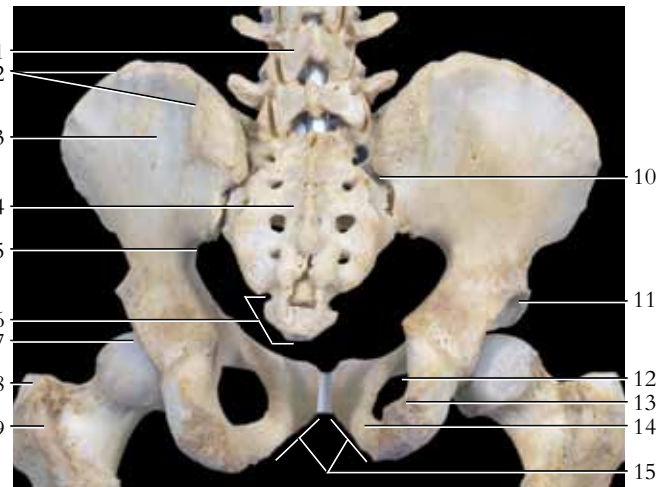
**Figure 6.14** A photograph (a) and a radiograph (b) showing polydactyly, having extra digits. Polydactyly is a common congenital deformity of the hand, although it also occurs in the foot. Notice that the carpal bones are still cartilaginous in a newborn and do not show up on a radiograph.





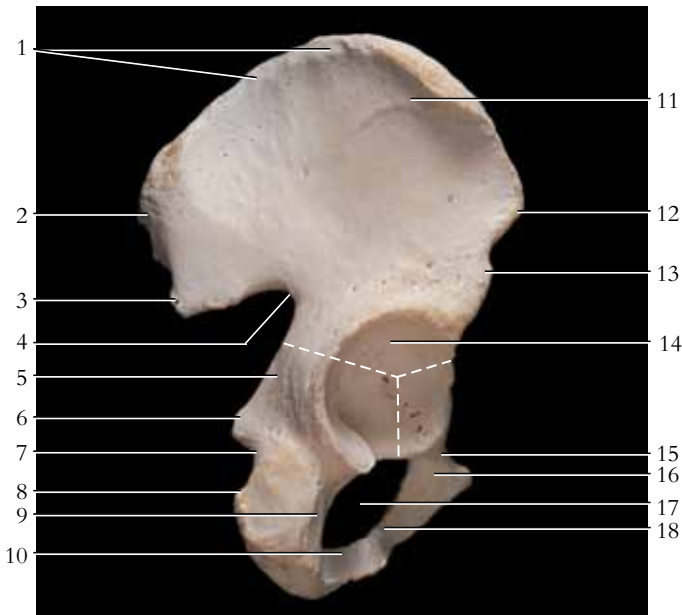
**Figure 6.15** An anterior view of the articulated pelvic girdle showing the two coxal bones, the sacrum, and the two femora.

- |                                  |                       |
|----------------------------------|-----------------------|
| 1. Lumbar vertebra               | 9. Crest of the ilium |
| 2. Intervertebral disc           | 10. Sacroiliac joint  |
| 3. Ilium                         | 11. Sacrum            |
| 4. Iliac fossa                   | 12. Pelvic brim       |
| 5. Anterior superior iliac spine | 13. Acetabulum        |
| 6. Head of femur                 | 14. Pubic crest       |
| 7. Greater trochanter            | 15. Obturator foramen |
| 8. Symphysis pubis               | 16. Ischium           |



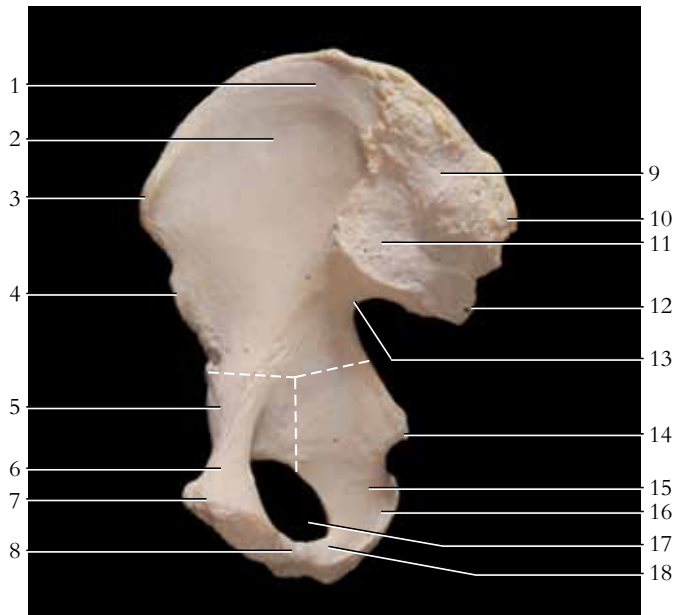
**Figure 6.16** A posterior view of the articulated pelvic girdle showing the two coxal bones, the sacrum, and the two femora.

- |                          |                            |
|--------------------------|----------------------------|
| 1. Lumbar vertebra       | 9. Intertrochanteric crest |
| 2. Crest of ilium        | 10. Sacroiliac joint       |
| 3. Ilium                 | 11. Acetabulum             |
| 4. Sacrum                | 12. Obturator foramen      |
| 5. Greater sciatic notch | 13. Ischium                |
| 6. Coccyx                | 14. Pubis                  |
| 7. Head of femur         | 15. Pubic angle            |
| 8. Greater trochanter    |                            |



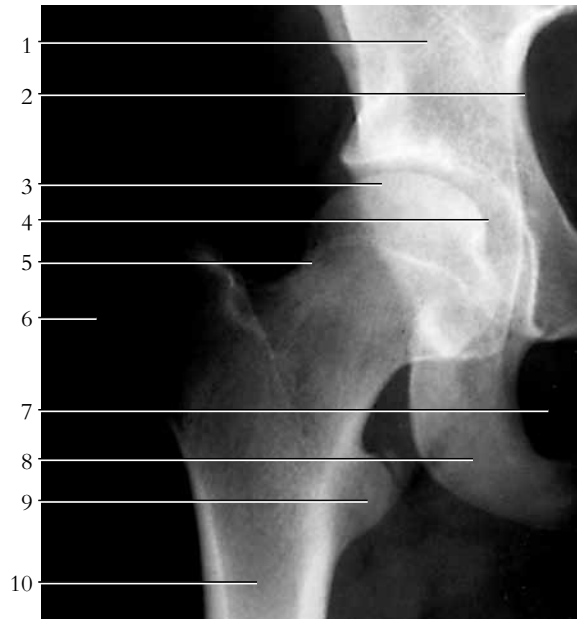
**Figure 6.17** A lateral view of the right os coxae.

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. Crest of the ilium             | 10. Ischial ramus                 |
| 2. Posterior superior iliac spine | 11. Ilium                         |
| 3. Posterior inferior iliac spine | 12. Anterior superior iliac spine |
| 4. Greater sciatic notch          | 13. Anterior inferior iliac spine |
| 5. Ischial body                   | 14. Acetabulum                    |
| 6. Ischial spine                  | 15. Superior ramus of pubis       |
| 7. Lesser sciatic notch           | 16. Pubis                         |
| 8. Ischial tuberosity             | 17. Obturator foramen             |
| 9. Ischium                        | 18. Inferior ramus of pubis       |



**Figure 6.18** A medial view of the right os coxae.

- |                                  |                                    |
|----------------------------------|------------------------------------|
| 1. Ilium                         | 10. Posterior superior iliac spine |
| 2. Iliac fossa                   | 11. Auricular surface              |
| 3. Anterior superior iliac spine | 12. Posterior inferior iliac spine |
| 4. Anterior inferior iliac spine | 13. Greater sciatic notch          |
| 5. Superior ramus of pubis       | 14. Ischial spine                  |
| 6. Pubis                         | 15. Ischium                        |
| 7. Pubic crest                   | 16. Lesser sciatic notch           |
| 8. Inferior pubic ramus          | 17. Obturator foramen              |
| 9. Iliac tuberosity              | 18. Ischial ramus                  |



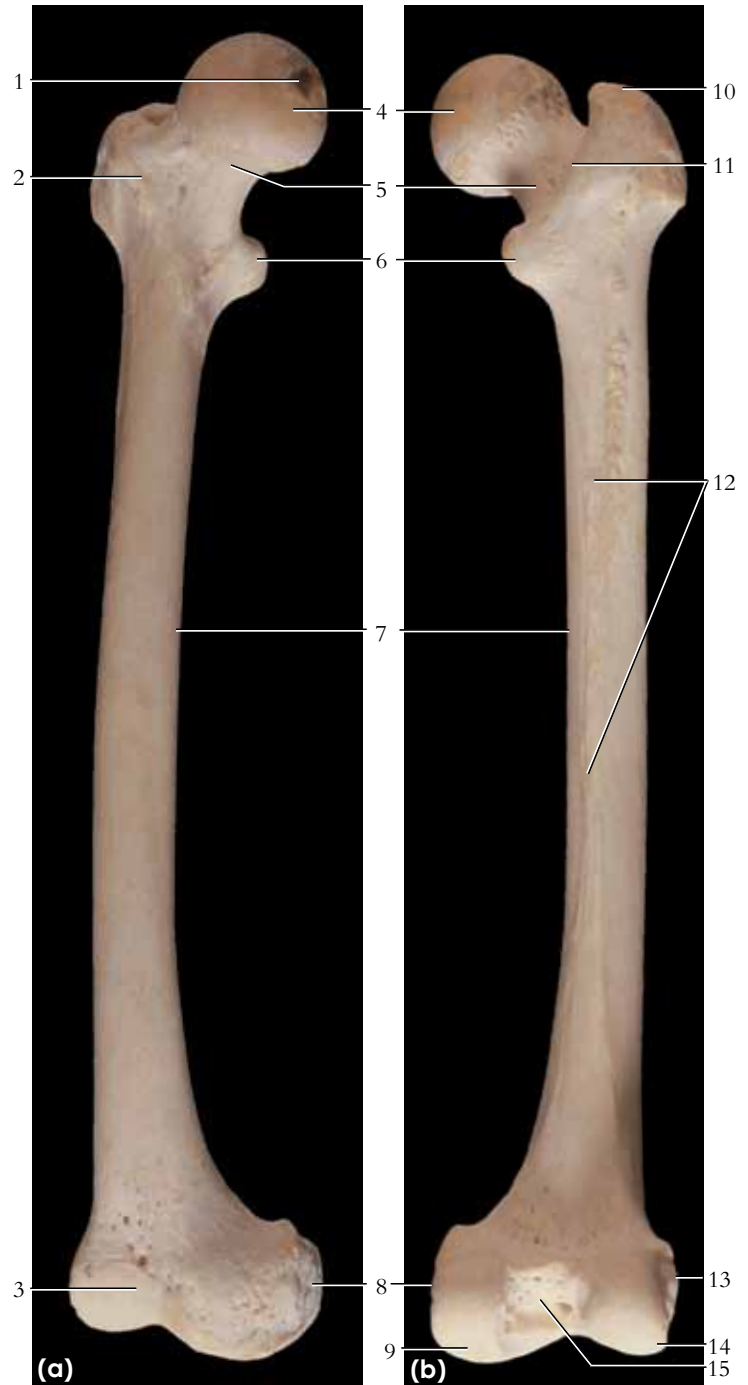
**Figure 6.19** A radiograph of the right os coxae and femur, anterior view.

- |                  |                       |
|------------------|-----------------------|
| 1. Ilium         | 6. Greater trochanter |
| 2. Pelvic brim   | 7. Obturator foramen  |
| 3. Head of femur | 8. Ischium            |
| 4. Acetabulum    | 9. Lesser trochanter  |
| 5. Neck of femur | 10. Femur             |



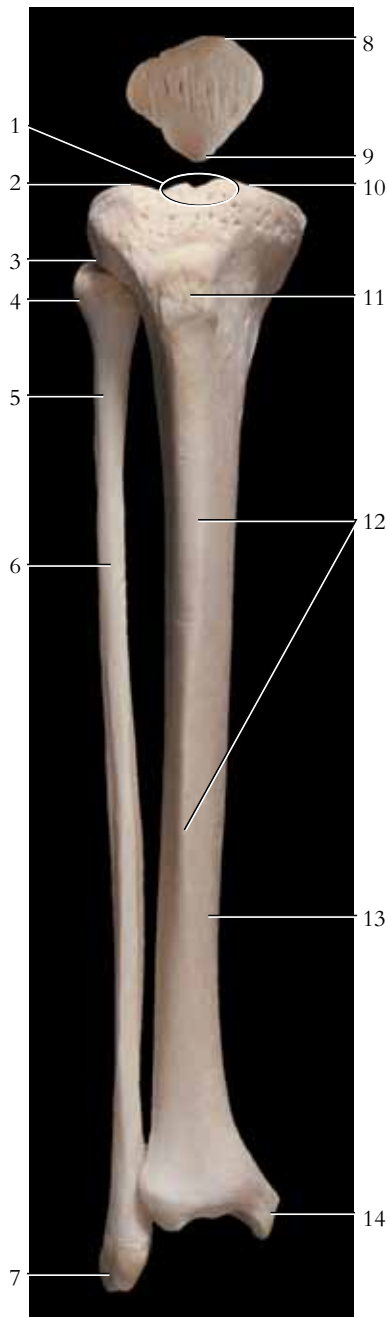
**Figure 6.20** A radiograph of the right knee region, medial view.

- |                     |                                     |
|---------------------|-------------------------------------|
| 1. Femur            | 6. Medial epicondyle of femur       |
| 2. Patella          | 7. Intercondylar eminences of tibia |
| 3. Condyle of femur | 8. Medial condyle of tibia          |
| 4. Tibia            |                                     |
| 5. Fibula           |                                     |



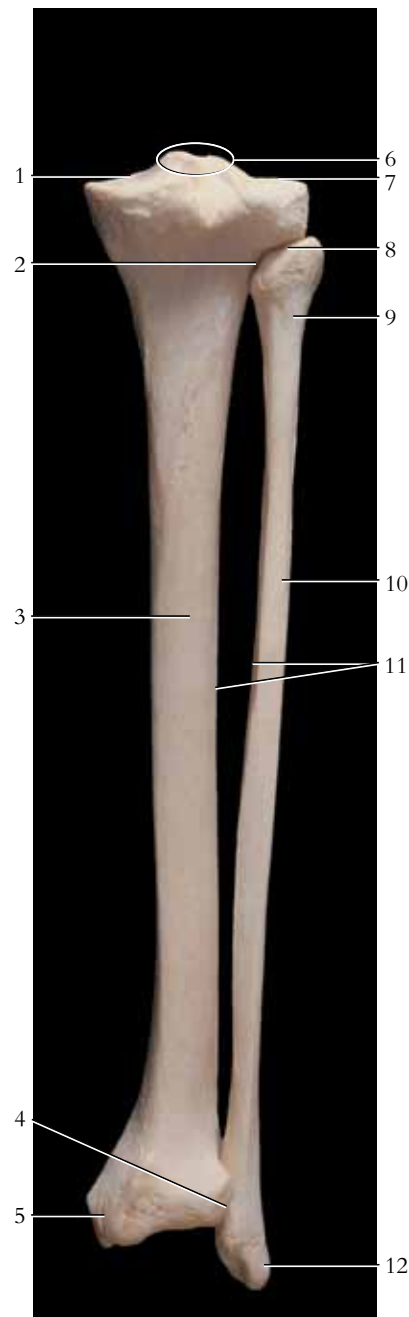
**Figure 6.21** The right femur (a) anterior view (b) posterior view.

- |                           |   |
|---------------------------|---|
| 1. Fovea capitis femoris  | 9. Medial condyle                         |
| 2. Intertrochanteric line | 10. Greater trochanter                    |
| 3. Patellar surface       | 11. Intertrochanteric crest               |
| 4. Head of femur          | 12. Linea aspera on body (shaft) of femur |
| 5. Neck of femur          | 13. Lateral epicondyle                    |
| 6. Lesser trochanter      | 14. Lateral condyle                       |
| 7. Body (shaft) of femur  | 15. Intercondylar fossa                   |
| 8. Medial epicondyle      |   |



**Figure 6.22** An anterior view of the right patella, tibia, and fibula.

1. Intercondylar tubercles
2. Lateral condyle
3. Tibial articular facet of fibula
4. Head of fibula
5. Neck of fibula
6. Body (shaft) of fibula
7. Lateral malleolus
8. Base of patella
9. Apex of patella
10. Medial condyle
11. Tibial tuberosity
12. Anterior crest of tibia
13. Body (shaft) of tibia
14. Medial malleolus

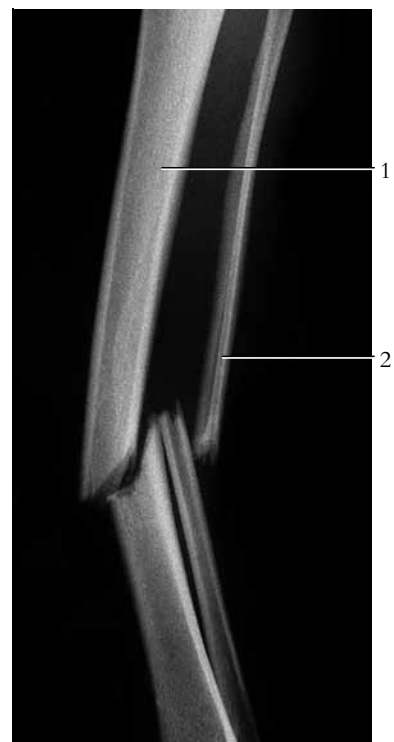


**Figure 6.23** A posterior view of the right tibia and fibula.

1. Medial condyle of tibia
2. Fibular articular facet of tibia
3. Body (shaft) of tibia
4. Fibular notch of tibia
5. Medial malleolus
6. Intercondylar tubercles
7. Lateral condyle of tibia
8. Head of fibula
9. Neck of fibula
10. Body (shaft) of fibula
11. Interosseous border
12. Lateral malleolus



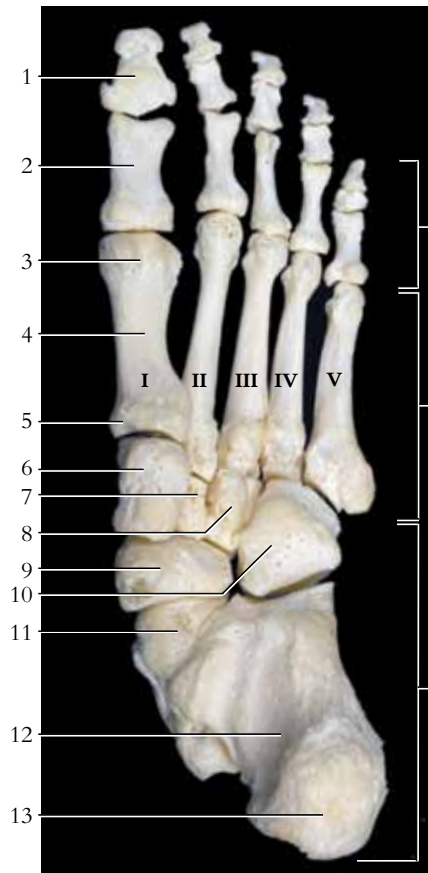
**Figure 6.24** A severe fracture of the leg and ankle (talus bone). In this patient, the trauma was so extensive amputation of the leg was necessary.



**Figure 6.25** A radiograph showing fractures of the tibia and fibula.

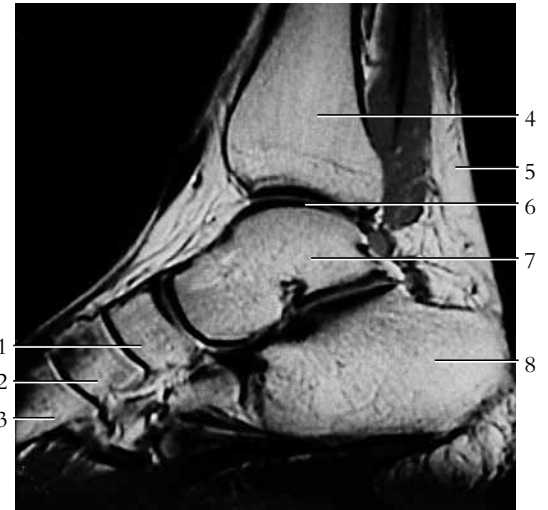
1. Tibia
2. Fibula





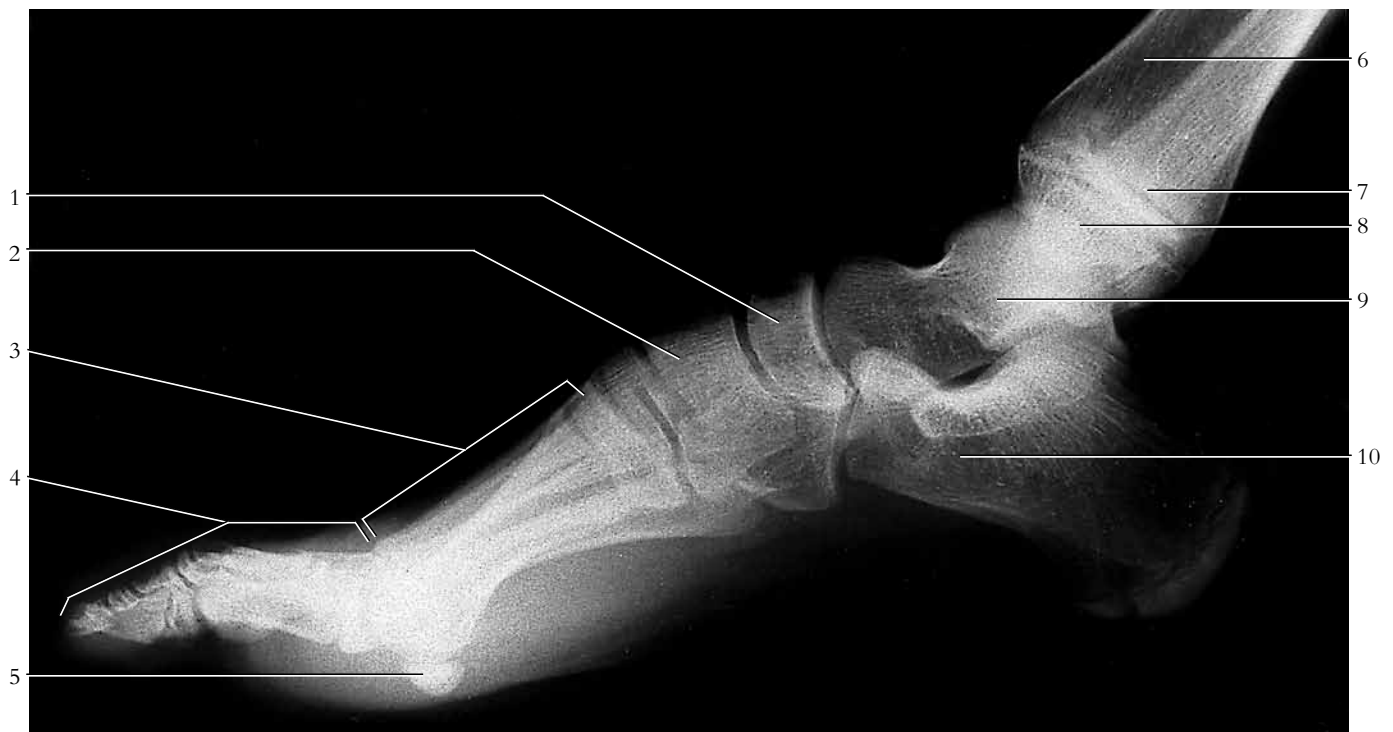
**Figure 6.26** An inferior view of the right foot.

1. Distal phalanx of first digit
2. Proximal phalanx of first digit
3. Head of first metatarsal bone
4. Body of first metatarsal bone
5. Base of first metatarsal bone
6. Medial cuneiform
7. Intermediate cuneiform
8. Lateral cuneiform
9. Navicular bone
10. Cuboid bone
11. Talus bone
12. Calcaneus bone
13. Tuberosity of calcaneus
14. Phalanges of fifth digit
15. Metatarsal bones (first-fifth)
16. Tarsal bones



**Figure 6.27** An MR image of the ankle region, medial view.

1. Navicular bone
2. Medial cuneiform
3. First metatarsal bone
4. Tibia
5. Tendo calcaneus
6. Tibiotalar joint
7. Talus
8. Calcaneus



**Figure 6.28** A radiograph of the right foot, medial view.

1. Navicular bone
2. First (medial) cuneiform
3. Metatarsal bones
4. Phalanges
5. Sesamoid bone
6. Tibia
7. Fibula (superimposed)
8. Tibiotalar joint
9. Talus
10. Calcaneus

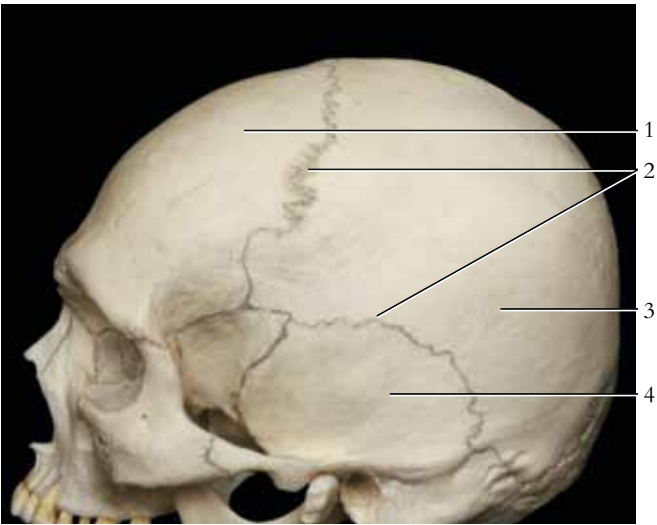
# Chapter 7

## Articulations

A joint is a region where bones articulate. The structure of a joint determines its range of movement. Not all joints are flexible, however, and as one part of the body moves, other joints remain rigid to stabilize the body and maintain balance. **Arthrology** is the study of joints and **kinesiology** is the study of body movement, or the functional relationship between the skeleton, joints, muscles, and innervation (nerve supply) as they work together to produce coordinated movement.

The joints of the body are structurally classified into three basic kinds:

1. **Fibrous joints**  
Fibrous connective tissues join the skeletal structures; the joints lack a joint capsule, but in some slight movement is possible.
2. **Cartilaginous joints**  
Fibrocartilage or hyaline cartilage joins the skeletal structures; the joints lack a joint capsule, but in some, slight movement is possible.
3. **Synovial joints**  
Joint capsules containing synovial fluid are present between the articulating bones; articular cartilages and ligaments supporting the articulating bones are also present, which permit freedom of movement. Synovial joints are the freely moveable joints of the body.

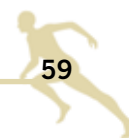


**Figure 7.1** A Suture located between cranial bones is a type of fibrous joint.

1. Frontal bone
2. Sutures
3. Parietal bone
4. Temporal bone

**Table 7.1** Movements permitted at synovial joints.

| Type of movement         | Description  |
|--------------------------|--|
| <b>Angular movement</b>  | Increase or decrease the joint angle   |
| Flexion                  | Decreasing the angle between two bones   |
| Extension                | Increasing the angle between two bones   |
| Hyperextension           | Excessive extension beyond 180° (angle of anatomical position)   |
| Dorsiflexion             | Bending the foot toward the tibia  |
| Plantar flexion          | Bending the foot away from the tibia   |
| Abduction                | Movement of a body part away from the axis of the body, or away from the midsagittal plane, in a lateral direction |
| Adduction                | Movement of a body part toward the axis of the body, or toward the midsagittal plane, in a mesial direction        |
| Inversion                | Movement of the sole of the foot inward, or medially   |
| Eversion                 | Movement of the sole of the foot outward, or laterally   |
| Opposition               | Movement of the thumb toward the surface of the palm   |
| Protraction              | Moving a part of the body anteriorly in the horizontal plane   |
| Retraction               | Moving a part of the body posteriorly in the horizontal plane  |
| Elevation                | Moving a part of the body in the superior direction  |
| Depression               | Moving a part of the body in the inferior direction  |
| <b>Circular movement</b> |  |
| Rotation                 | Turning of a bone at joint axis  |
| Pronation                | Rotation of the forearm causing the wrist and hand to go from palm facing front to palm facing back                |
| Supination               | Rotation of the forearm causing the wrist and hand to go from palm facing back to palm facing front                |
| Circumduction            | Movement of a body segment in a circular, conelike motion  |

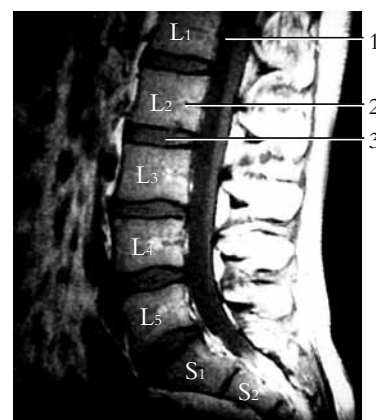
**Table 7.2** Types of joints.

| Type                 | Structure and movement   | Example  |
|----------------------|--|--|
| <b>Fibrous</b>       | Fibrous connective tissue joins the skeletal structures  |  |
| Suture               | Frequently serrated edges of articulating bones, separated by a thin layer of fibrous tissue; no movement                | Joints between cranial bones   |
| Syndesmosis          | Articulating bones bound by an interosseous ligament; slight movement  | Joints between tibia-fibula and radius-ulna  |
| Gomphosis            | Periodontal ligament binding teeth into dental aveoli of bone; no movement   | Teeth secured in the dental alveoli (teeth sockets)  |
| <b>Cartilaginous</b> | Fibrocartilage or hyaline cartilage joins the skeletal structures  |  |
| Symphysis            | Thin pad of fibrocartilage between articulating bones; slight movement   | Symphysis pubis, and intervertebral joints (discs)   |
| Synchondrosis        | Mitotically active hyaline cartilage between skeletal structures; no movement  | Epiphyseal plates between diaphysis and epiphyses of long bones; ribs and costal cartilages            |
| <b>Synovial</b>      | Joint capsule between articulating bones, containing synovial fluid; extensive movement                                  |  |
| Gliding              | Flattened or slightly curved articulating surfaces; sliding movement   | Intercarpal and intertarsal joints   |
| Hinge                | Concave surface of one bone articulates with a depression of another; bending motion in one plane                        | Humeroulnar (elbow) and tibiofemoral (knee) joints; inter-phalangeal (finger and toe) joints of digits |
| Pivot                | Conical surface of one bone articulates with a depression of another; rotation about a central axis; rotational movement | Atlantoaxial joint; proximal radioulnar joint  |
| Condylloid           | Oval condyle of one bone articulates with elliptical cavity of another; biaxial movement                                 | Radiocarpal (wrist) joint  |
| Saddle               | Concave and convex surface on each articulating bone; wide range of movement; biaxial movement                           | Carpometacarpal joint at the base of the thumb   |
| Ball-and-socket      | Rounded convex surface of one bone articulates with cuplike socket of another; movement in all planes and rotation       | Glenohumeral (shoulder) and coxal (hip) joints   |



**Figure 7.2** A symphysis is a type of cartilaginous joint. The symphysis pubis can be readily seen in this radiograph of the pelvic girdle. Note the head of the femur articulating with the acetabulum of the os coxae forming a ball-and-socket joint is a freely moveable synovial joint.

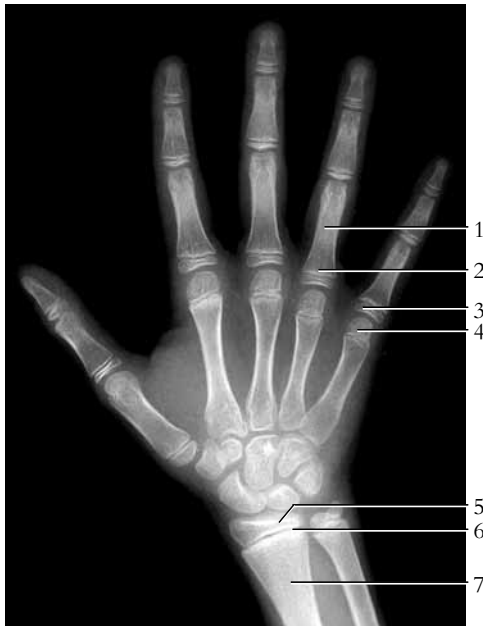
1. Ilium
2. Acetabulum
3. Ball-and-socket joint
4. Head of femur
5. Pubis
6. Symphysis pubis



**Figure 7.3** An intervertebral joint between vertebral bodies is a type of cartilaginous joint. The intervertebral discs of intervertebral joints can be readily seen in a lateral MR image of the lower back.

1. Spinal cord
2. Body of second lumbar vertebra (L2)
3. Intervertebral disc





**Figure 7.4** A synchondrosis is a type of cartilaginous joint located within a long bone at both the proximal and the distal epiphyseal plates as seen in a radiograph of a child's hand. Mitotic activity at a synchondrotic joint is responsible for linear (length) bone growth.

1. Diaphysis of phalanx
2. Epiphyseal plate
3. Proximal epiphysis of phalanx
4. Distal epiphysis of metacarpal bone
5. Distal epiphysis of radius
6. Epiphyseal plate
7. Diaphysis of radius



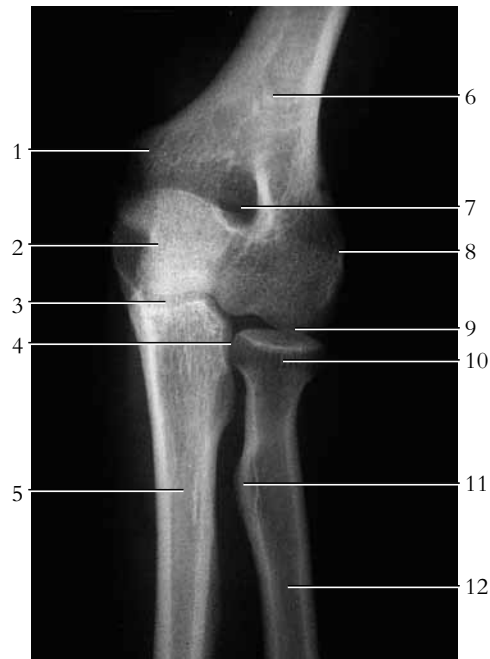
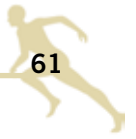
**Figure 7.5** The side-to-side articulation of the ulna and radius forms a syndesmosis that is tightly bound by an interosseous ligament (not seen in radiograph). A syndesmosis is a type of fibrous joint that permits slight movement.

1. Sesamoid bone
2. Carpal bones
3. Syndesmosis
4. Radius
5. Ulna



**Figure 7.6** Radiographs of the (a) wrist and hand and (b) the ankle and foot. Several kinds of synovial joints (freely moveable joints) are contained in these regions.

1. Hinge joints—interphalangeal joints of the second digit (index finger)
2. Condylod joint—metacarpophalangeal joint of the second digit (index finger)
3. Saddle joint—carpometacarpal joint of the pollex (thumb)
4. Gliding joint—intercarpal joint between capitate and scaphoid bones
5. Condylod joint—radiocarpal joint
6. Condylod joint at the ankle
7. Gliding joints between tarsal bones
8. Hinge joint between phalanges of digit



**Figure 7.7** A radiograph of the elbow region depicting two types of synovial joints. The humeroulnar joint is a hinge joint that permits movement along a single plane. The proximal radioulnar and humeroradial joints are both pivot joints that permit rotational movement.

- |                              |                       |
|------------------------------|-----------------------|
| 1. Medial epicondyle         | 7. Olecranon fossa    |
| 2. Olecranon                 | 8. Lateral epicondyle |
| 3. Humeroulnar joint         | 9. Humeroradial joint |
| 4. Proximal radioulnar joint | 10. Head of radius    |
| 5. Ulna                      | 11. Radial tuberosity |
| 6. Humerus                   | 12. Radius            |



**Figure 7.8** The ball-and-socket joint seen in this radiograph of the hip is a synovial joint. The coxal joint (hip joint) is formed by the head of the femur articulating with the acetabulum of the os coxae.

- |                          |                       |
|--------------------------|-----------------------|
| 1. Ilium                 | 6. Greater trochanter |
| 2. Acetabulum            | 7. Obturator foramen  |
| 3. Ball-and-socket joint | 8. Ischium            |
| 4. Head of femur         | 9. Femur              |
| 5. Pubis                 |                       |



**Figure 7.9** The ball-and-socket joint seen in this radiograph of the shoulder is a synovial joint. The glenohumeral joint (shoulder joint) is formed by the head of the humerus articulating with the glenoid fossa of the scapula.

- |                          |
|--------------------------|
| 1. Head of humerus       |
| 2. Ball-and-socket joint |
| 3. Humerus               |
| 4. Glenoid fossa         |
| 5. Scapula               |



(a)

Flexion at left shoulder, elbow, and knee joints. Extension of right shoulder, and elbow.



(b)

Maximal flexion at each of the principal body joints.



(c)

Rotation at the joints of the neck; elevation at the shoulder joint; and flexion at the right elbow and right wrist joints.



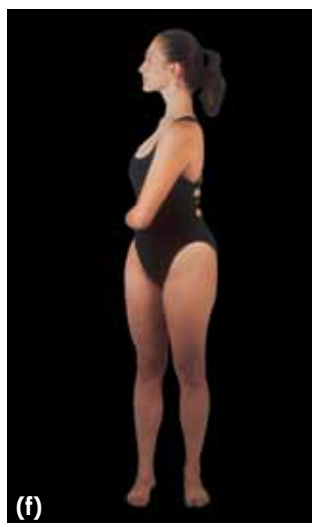
(d)

Abduction at the shoulder and hip joints. Also, abduction at the metacarpophalangeal joints at the base of the digits.



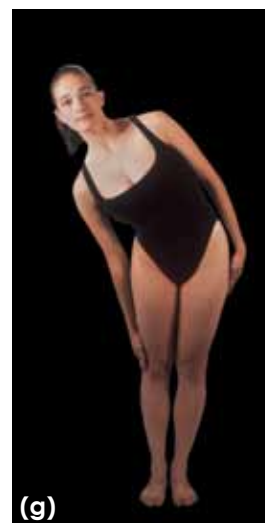
(e)

Adduction at the shoulder and hip joints. Also, adduction at the joints of the fingers and toes.



(f)

Lateral (right and left) rotation at joints of the vertebral column.



(g)

Lateral bending (flexion) at joints of the vertebral column.



(h)

Flexion at the joints of the vertebral column.



(i)

Hyperextension at the joints of the vertebral column.



(j)

Flexion at the shoulder, hip, and knee joints on left side of body; extension at the elbow and wrist joints; knee extension on right side of body.



(k)

Hyperextension at the shoulder and hip joints on left side of body. Plantar flexion at the left ankle joint.

**Figure 7.10** A photographic summary of joint movements (a-k).

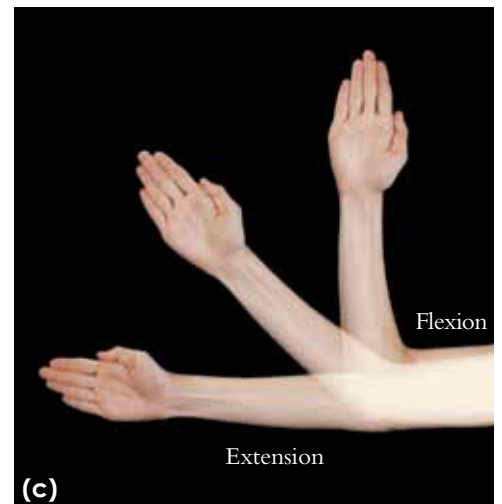




(a) Hyperextension, extension, and flexion at the cervical intervertebral joints of the neck.



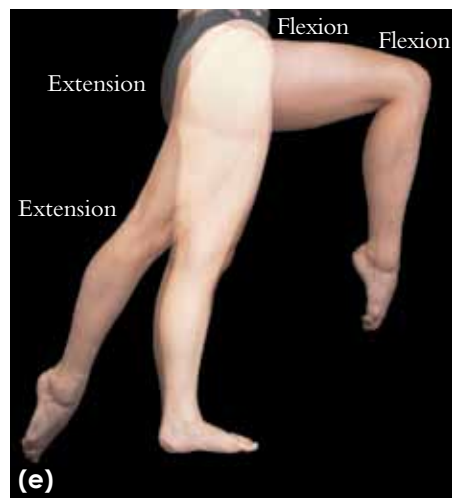
(b) Adduction and abduction of the right arm at the shoulder joint and fingers at the metacarpophalangeal joints.



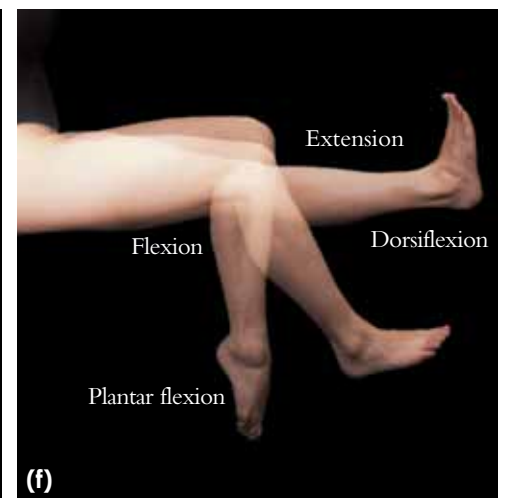
(c) Flexion and extension at the right elbow joint.



(d) Abduction and adduction of the right hand at the wrist.

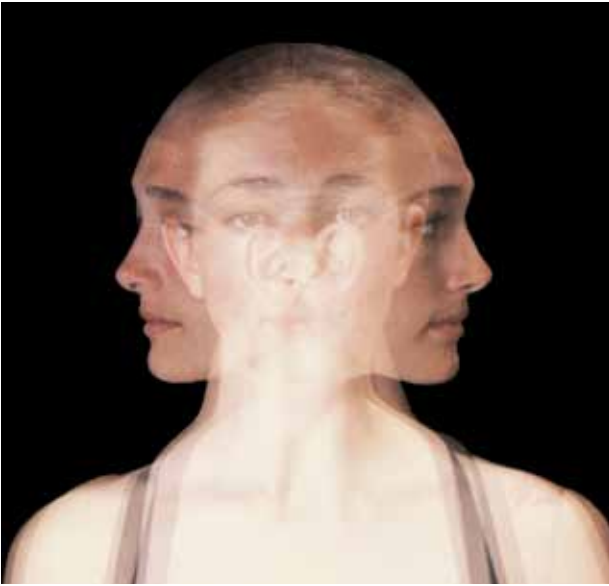


(e) Flexion and extension at the right hip and knee joints.



(f) Flexion and extension at the knee joint and plantar flexion and dorsiflexion at the ankle joint.

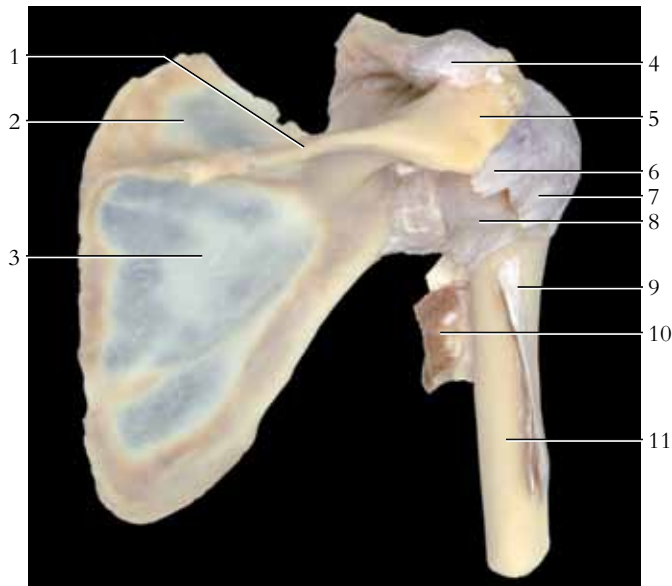
**Figure 7.11** A visualization of angular movements permitted at synovial joints (a-f).



**Figure 7.12** Rotation of the head at the cervical vertebrae—principally at the atlantoaxial joint.

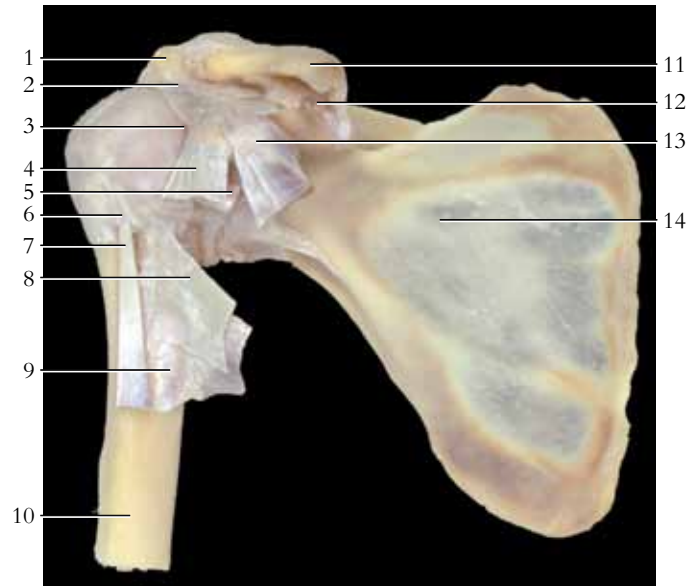


**Figure 7.13** Rotation of the antebrachium (forearm) at the proximal radioulnar joint—an example of pronation and supination.



**Figure 7.14** A posterior view of the right scapula, proximal humerus, and glenohumeral (shoulder) joint.

1. Spine of scapula
2. Supraspinous fossa
3. Infraspinous fossa
4. Coracoacromial ligament
5. Acromion
6. Tendon of infraspinatus muscle
7. Tendon of teres minor muscle
8. Articular capsule of glenohumeral joint
9. Origin of lateral head of triceps brachii muscle
10. Teres major muscle
11. Humerus



**Figure 7.15** An anterior view of the right scapula, proximal humerus, and glenohumeral (shoulder) joint.

1. Acromion
2. Coracoid process of scapula
3. Articular capsule of glenohumeral joint
4. Tendon of short head of biceps brachii muscle
5. Tendon of coracobrachialis muscle
6. Tendon sheath
7. Tendon of long head of biceps brachii muscle
8. Tendon of latissimus dorsi muscle
9. Tendon of teres major muscle
10. Humerus
11. Clavicle
12. Subclavius muscle
13. Tendon of pectoralis minor muscle
14. Subscapular fossa



**Figure 7.16** The structure of the humeral joint (shoulder joint) as seen in a MR image.

1. Subdeltoid bursa
2. Articular cavity of shoulder joint
3. Head of humerus



**Figure 7.17** An anterior view of the right elbow region.

1. Humerus
2. Lateral epicondyle of humerus
3. Articular capsule of elbow joint
4. Annular ligament
5. Head of radius
6. Radius
7. Medial epicondyle
8. Ulnar collateral ligament
9. Ulna

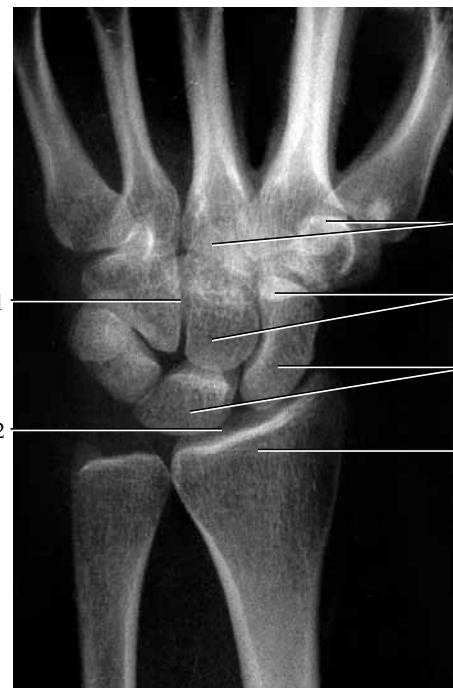


**Figure 7.18** A posterior view of the right elbow region.

1. Olecranon fossa
2. Articular capsule of elbow joint
3. Medial epicondyle
4. Olecranon
5. Ulna
6. Humerus
7. Lateral epicondyle
8. Head of radius
9. Radius

**Figure 7.19** The structure of the elbow joint as seen in a radiograph.

1. Articular cavity of elbow joint
2. Head of radius
3. Neck of radius
4. Radial tuberosity
5. Radius
6. Humerus
7. Olecranon
8. Ulna



**Figure 7.20** The structure of the wrist joint as seen in a MR image.

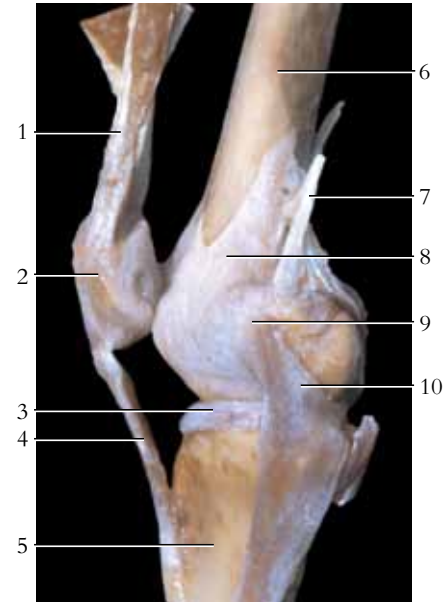
1. Gliding joint
2. Condylod joint
3. Heads of second and third metacarpal bones
4. Distal carpal bones (trapezoid and capitate bones)
5. Proximal carpal bones (scaphoid and lunate bones)
6. Distal epiphysis of radius





**Figure 7.21** The structure of the coxal joint (hip joint) as seen in a MR image.

1. Acetabulum
2. Articular cavity of hip joint
3. Head of femur
4. Greater trochanter of femur
5. Lesser trochanter of femur
6. Body of femur

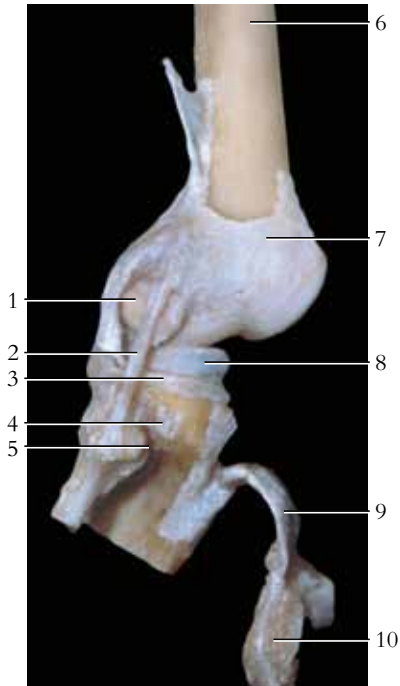


**Figure 7.22** A medial view of the right tibiofemoral (knee) joint

1. Tendon of quadriceps femoris muscle
2. Patella
3. Medial meniscus
4. Patellar ligament
5. Tibia
6. Femur
7. Tendon of adductor magnus muscle
8. Articular capsule of tibiofemoral (knee) joint
9. Medial epicondyle of femur
10. Tibial collateral ligament

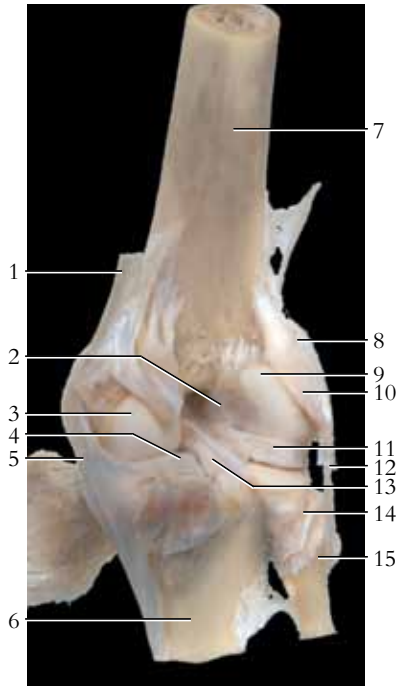
**Figure 7.23** A lateral view of right tibiofemoral (knee) joint.

1. Bursa
2. Lateral collateral ligament
3. Articular cartilage
4. Proximal epiphysis
5. Tibiofibular joint
6. Femur
7. Articular capsule
8. Lateral meniscus
9. Patellar ligament
10. Patella



**Figure 7.24** A posterior view of right tibiofemoral (knee) joint.

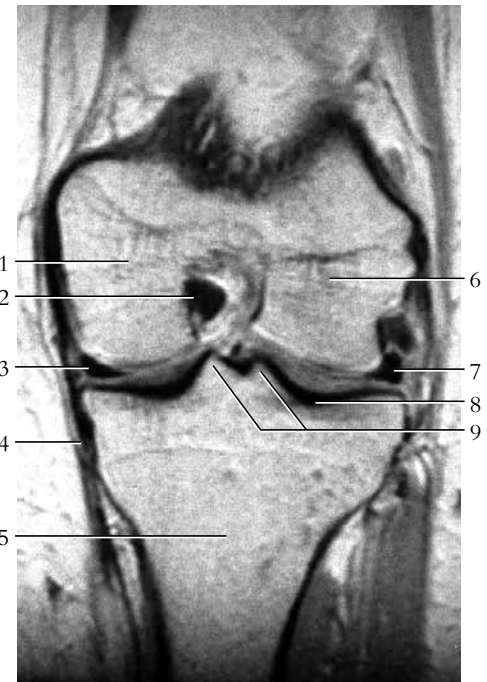
1. Tendon of adductor magnus muscle
2. Anterior cruciate ligament
3. Medial femoral condyle
4. Medial meniscus
5. Medial collateral ligament
6. Tibia
7. Femur
8. Lateral epicondyle of femur
9. Lateral femoral condyle
10. Tendon of popliteus muscle
11. Lateral meniscus
12. Lateral collateral ligament
13. Posterior cruciate ligament
14. Proximal tibiofibular joint
15. Head of fibula





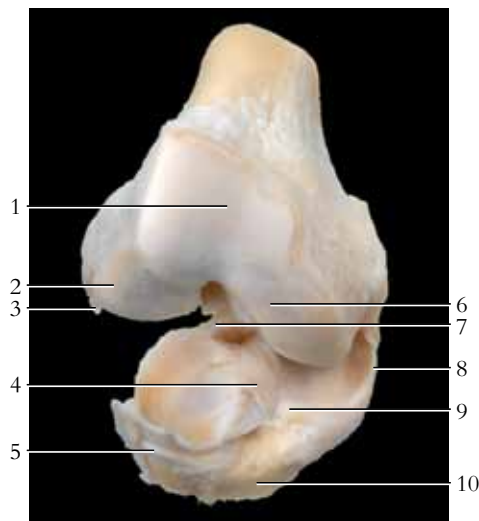
**Figure 7.25** A sagittal MR image of tibiofemoral joint (knee joint).

- |                                    |                                     |
|------------------------------------|-------------------------------------|
| 1. Tendon of quadriceps muscle     | 7. Gastrocnemius muscle             |
| 2. Patella                         | 8. Lateral meniscus, posterior horn |
| 3. Patellar ligament               | 9. Synovial fluid                   |
| 4. Lateral meniscus, anterior horn | 10. Articular cartilage             |
| 5. Head of tibia                   | 11. Head of fibula                  |
| 6. Femur                           |                                     |



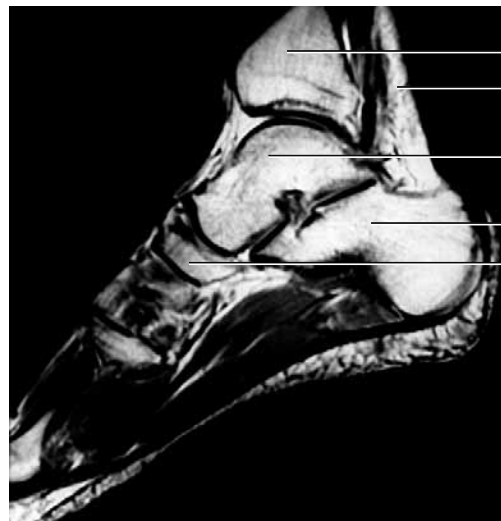
**Figure 7.26** A posterior MR image of tibiofemoral joint (knee joint).

- |   |                             |
|---|-----------------------------|
| 1. Medial condyle                           | 6. Lateral condyle of femur |
| 2. Insertion of posterior cruciate ligament | 7. Lateral meniscus         |
| 3. Medial meniscus                          | 8. Synovial fluid           |
| 4. Tibial collateral ligament               | 9. Intercondylar eminences  |
| 5. Tibia                                    |                             |



**Figure 7.27** An anterior view of right tibiofemoral (knee) joint as it is flexed.

- |                                 |
|---------------------------------|
| 1. Patellar articular surface   |
| 2. Lateral femoral condyle      |
| 3. Lateral collateral ligament  |
| 4. Anterior cruciate ligament   |
| 5. Articular cartilage of tibia |
| 6. Medial femoral condyle       |
| 7. Posterior cruciate ligament  |
| 8. Medial collateral ligament   |
| 9. Medial meniscus              |
| 10. Tibia                       |



**Figure 7.28** A sagittal MR image of the talocrural (ankle) and tarsal joints of the foot.

- |                    |                   |
|--------------------|-------------------|
| 1. Tibia           | 4. Calcaneus      |
| 2. Tendo calcaneus | 5. Navicular bone |
| 3. Talus           |                   |



**Figure 7.29** A radiograph of the hip showing a joint prosthesis.

# Chapter 8

## Muscular System

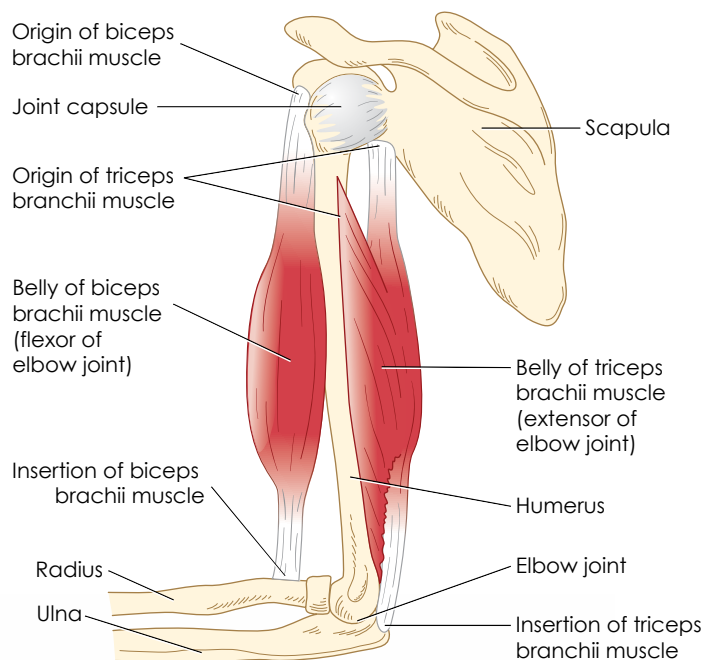
Most skeletal muscles span joints and are attached to a bone at both ends by a **tendon**. Certain tendons, especially at the wrist and ankle, are enclosed individually by **tendon sheaths**. A group of tendons in these areas is also covered by a **retinaculum**. The **origin** of a muscle is the more stationary attachment, and the **insertion** is the more moveable attachment (fig. 8.1). **Synergistic muscles** contract together. **Antagonistic muscles** perform in opposition to a synergistic group of muscles.

**Fascia** is a fibrous connective tissue that covers muscle and attaches to the skin. **Superficial fascia** secures the skin to the underlying muscle. **Deep fascia** is an inward extension of the superficial fascia and surrounds adjacent muscles compartmentalizing and binding them into functional groups.

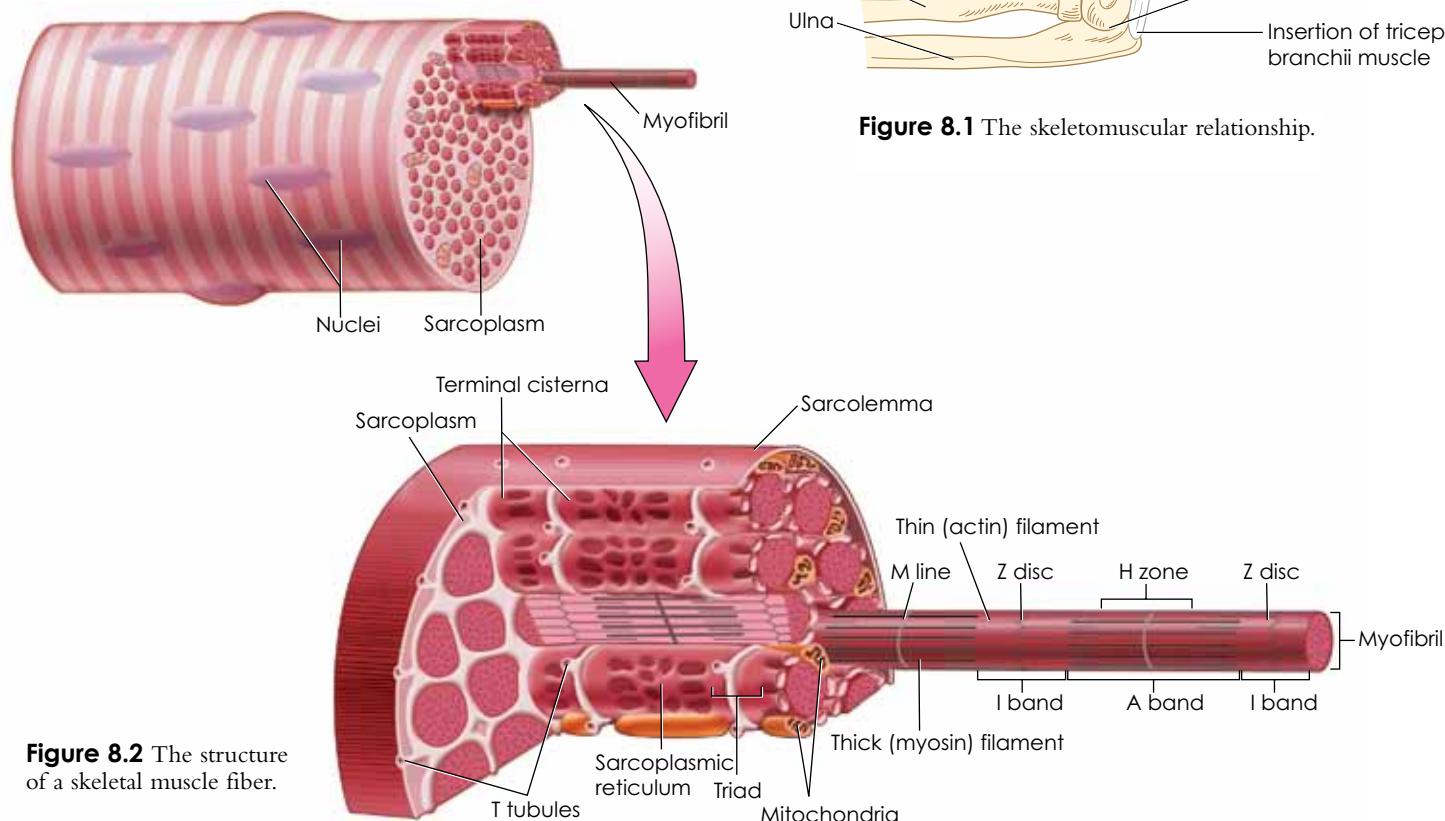
A skeletal muscle fiber is an elongated, multinucleated, striated cell (fig. 8.2). Each fiber is surrounded by a cell membrane, called a **sarcolemma**, and the cytoplasm within the cell is called **sarcoplasm**. Each fiber contains many parallel, thread-like structures called **myofibrils**. Each myofibril is composed of smaller strands called **myofilaments** that contain the contractile proteins **actin** and **myosin**. The regular spatial organization of the contractile proteins within the myofibrils forms the cross-banding striations characteristic of skeletal muscle. A network of membranous channels, called the **sarcoplasmic reticulum**, extends throughout the cytoplasm.

The myofibrils of a skeletal muscle fiber are arranged into compartments called **sarcomeres**. The dark and light striations of the sarcomere are due to the arrangement of the thick (myosin) and thin (actin) filaments. The dark bands are called **A-bands** and the lighter bands, containing only actin filaments, are

called **I-bands**. The outer regions of the A bands contain actin and myosin; however, the lighter central regions (**H-zones**) of the A bands contain only myosin. The I bands are bisected by dark **Z-lines** where the actin filaments of adjacent sarcomeres join. Muscle fiber contraction results from the interaction of contractile proteins (actin and myosin myofilaments) in which the length of the sarcomeres is reduced.

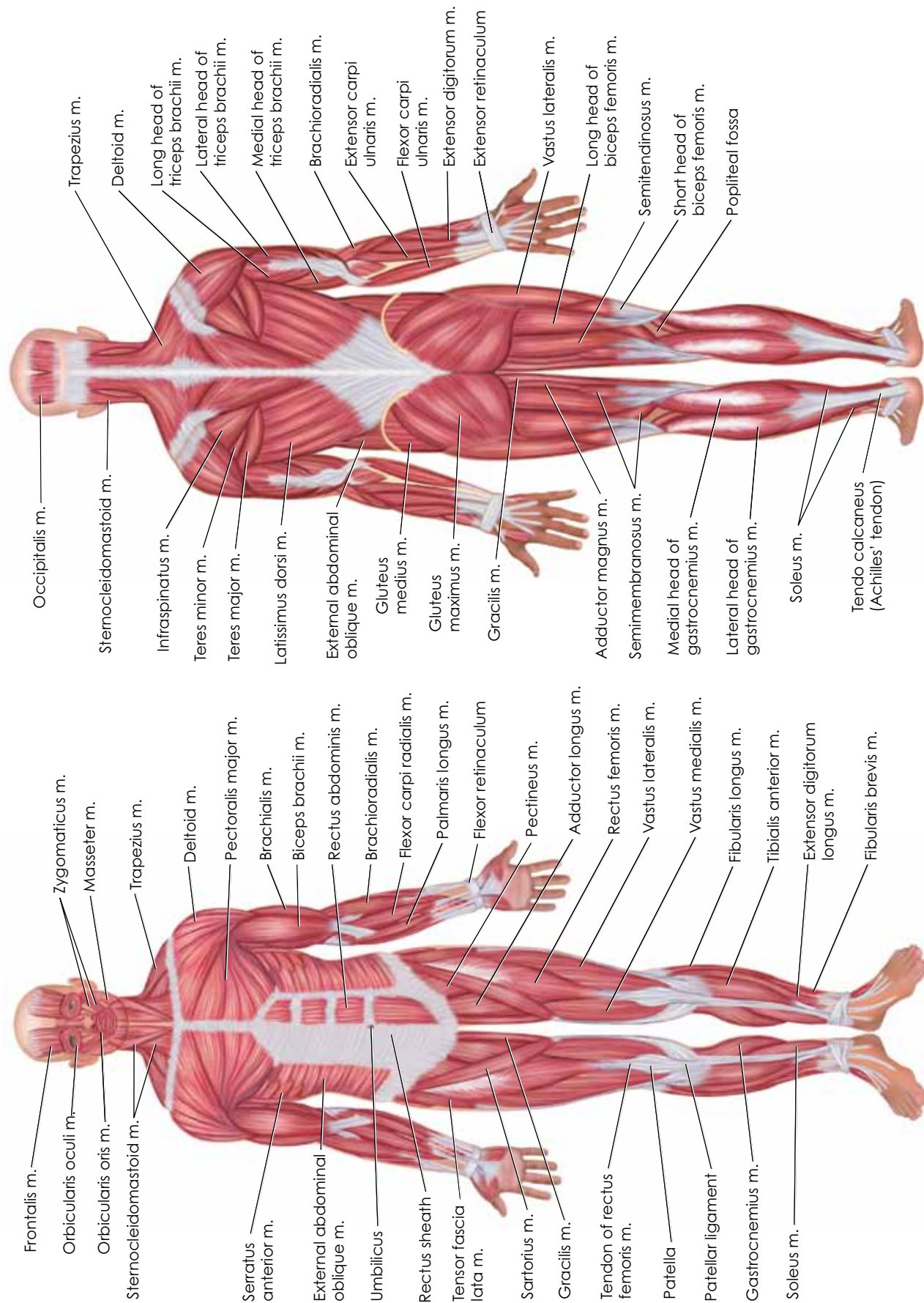


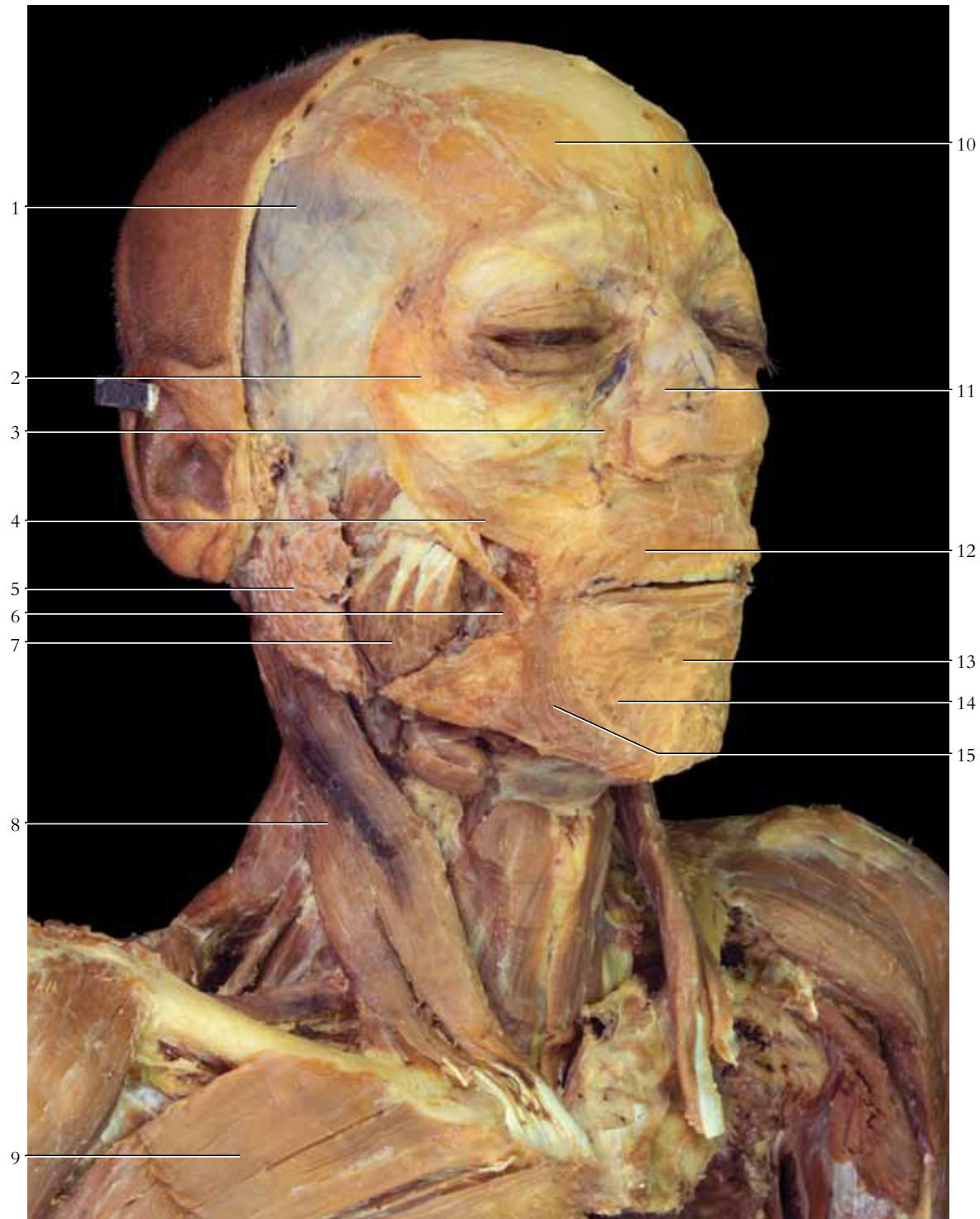
**Figure 8.1** The skeletomuscular relationship.



**Figure 8.2** The structure of a skeletal muscle fiber.



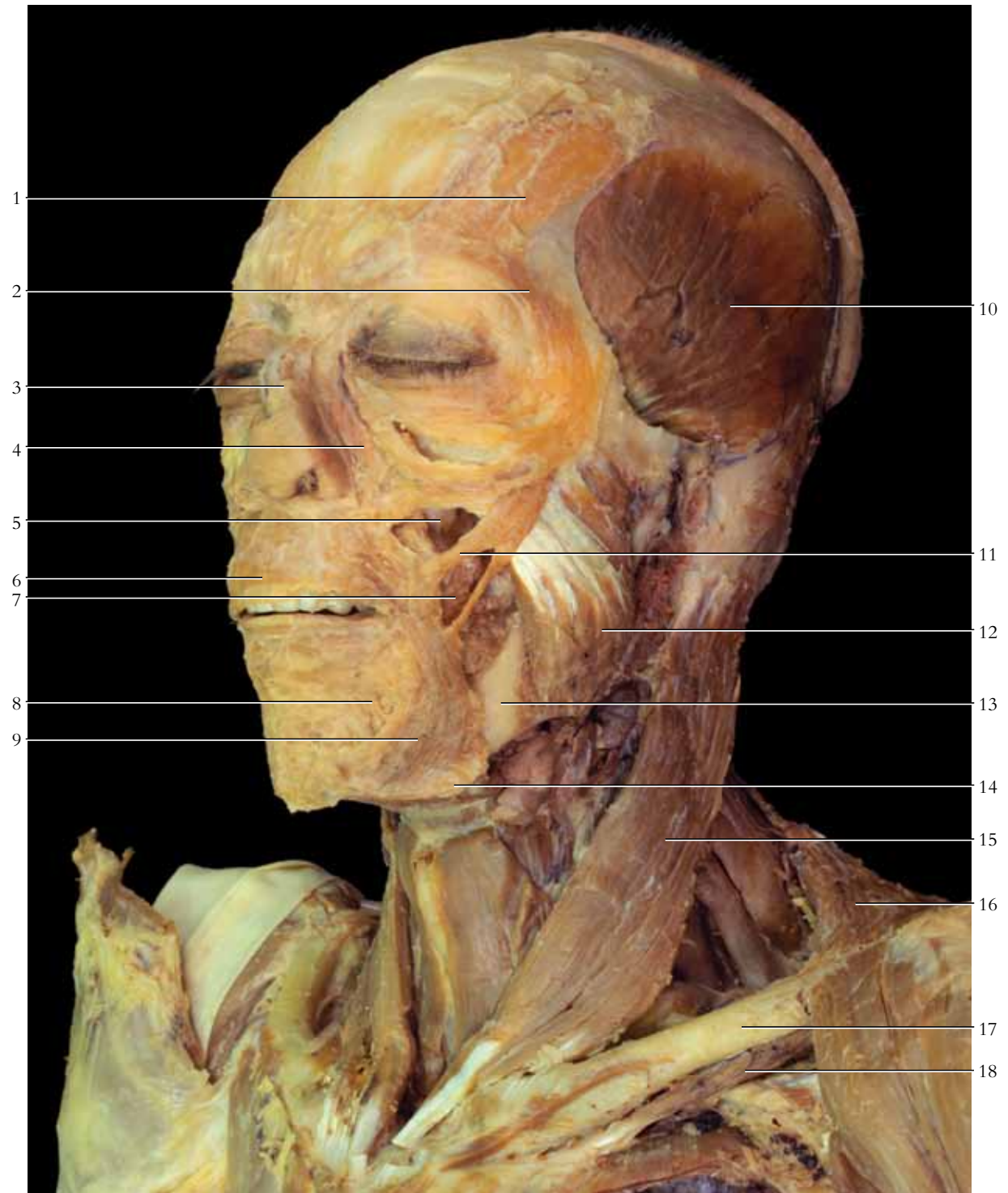
**Figure 8.3** An anterior view of human musculature (m.=muscle).**Figure 8.4** A posterior view of human musculature (m.=muscle).



**Figure 8.5** The muscles of the anterolateral head and neck regions.

- |                                |                           |                                   |
|--------------------------------|---------------------------|-----------------------------------|
| 1. Temporalis m.               | 7. Masseter m.            | 13. Mentalis m.                   |
| 2. Orbicularis oculi m.        | 8. Sternocleidomastoid m. | 14. Depressor labii inferioris m. |
| 3. Levator labii superioris m. | 9. Pectoralis major m.    | 15. Depressor anguli oris m.      |
| 4. Zygomaticus major m.        | 10. Frontalis m.          |                                   |
| 5. Parotid gland               | 11. Nasalis m.            |                                   |
| 6. Buccinator m.               | 12. Orbicularis oris m.   |                                   |

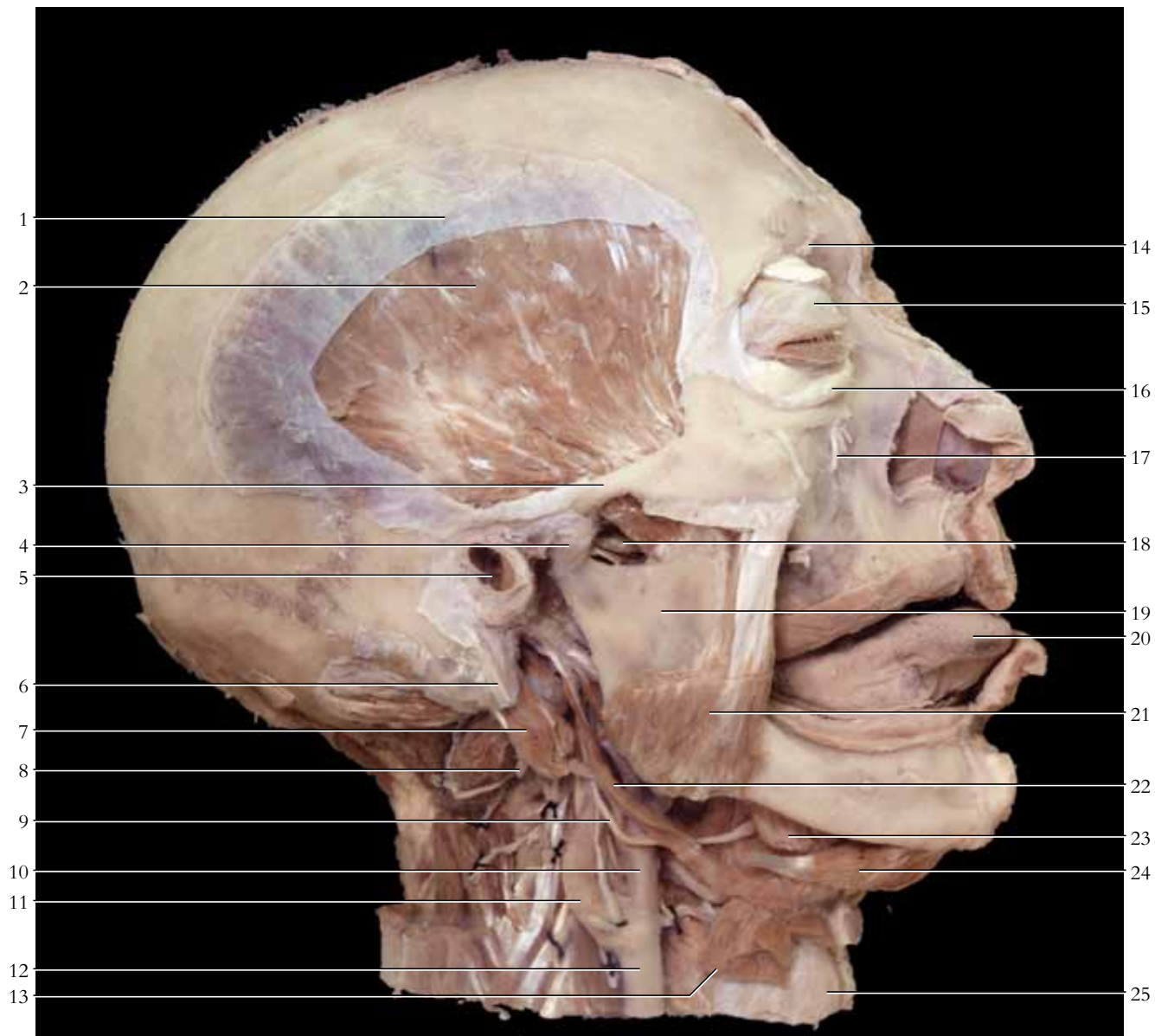




**Figure 8.6** The muscles of the anterolateral head and neck regions.

- |                                |                                  |                            |
|--------------------------------|----------------------------------|----------------------------|
| 1. Frontalis m.                | 7. Buccinator m.                 | 13. Mandible               |
| 2. Orbicularis oculi m.        | 8. Depressor labii inferioris m. | 14. Platysma m. (cut)      |
| 3. Nasalis m.                  | 9. Depressor anguli oris m.      | 15. Sternocleidomastoid m. |
| 4. Levator labii superioris m. | 10. Temporalis m.                | 16. Trapezius m.           |
| 5. Levator anguli oris m.      | 11. Zygomaticus major m.         | 17. Clavicle               |
| 6. Orbicularis oris m.         | 12. Masseter m.                  | 18. Subclavius m.          |





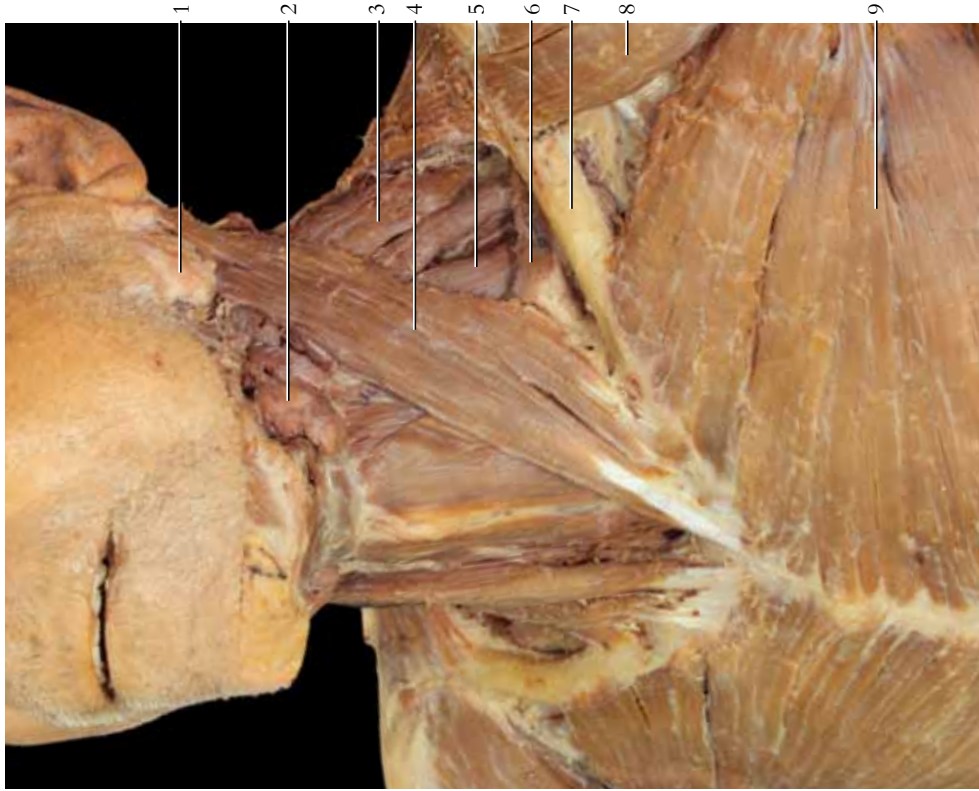
**Figure 8.7** A lateral view of the deep structures of the head and neck.

- |   |                             |  |
|---|-----------------------------|--|
| 1. Temporal fascia                          | 10. External carotid artery | 19. Mandible                           |
| 2. Temporalis m.                            | 11. Internal carotid artery | 20. Tongue                             |
| 3. Zygomatic arch                           | 12. Common carotid artery   | 21. Masseter m. (cut)                  |
| 4. Joint capsule of temporomandibular joint | 13. Omohyoid m. (cut)       | 22. Stylohyoid m.                      |
| 5. External acoustic canal                  | 14. Supraorbital nerve      | 23. Mylohyoid m.                       |
| 6. Mastoid process of temporal bone         | 15. Superior tarsal plate   | 24. Anterior belly of digastric muscle |
| 7. Posterior belly of digastric m.          | 16. Palpebral fascia        | 25. Thyroid cartilage of larynx        |
| 8. Vagus nerve (cut)                        | 17. Infraorbital nerve      |  |
| 9. Hypoglossal nerve                        | 18. Lateral pterygoid m.    |  |



**Figure 8.8** An anterior view of the neck muscles.

1. Mylohyoid m.
2. Submandibular gland
3. Omohyoid m.
4. Sternohyoid m.
5. Clavicle
6. Pectoralis major m.
7. Digastric m. (anterior belly)
8. Hyoid bone
9. Sternocleidomastoid m.



**Figure 8.9** An anterolateral view of the neck muscles.

1. Parotid gland
2. Submandibular gland
3. Levator scapulae m.
4. Sternocleidomastoid m.
5. Middle scalene m.
6. Omohyoid m.
7. Clavicle
8. Deltoid m.
9. Pectoralis major m.





**Figure 8.10** An anterolateral view of the neck muscles.

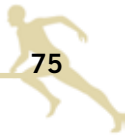
1. Thyroid cartilage
2. Thyrohyoid m.
3. Sternocleidomastoid m.
4. Levator scapulae m.
5. Omohyoid m. (superior belly)
6. Omohyoid m. (inferior belly)
7. Clavicle
8. Subclavius m.



**Figure 8.11** An anterolateral view of the neck muscles.

1. Thyroid cartilage
2. Thyrohyoid m.
3. Sternocleidomastoid m.
4. Sternocleidomastoid m. (cut and reflected)
5. Levator scapulae m.
6. Internal jugular vein
7. Middle scalene m.
8. Omohyoid m.
9. Brachial plexus
10. Clavicle
11. Anterior scalene m.



**Table 8.1** Muscles of facial expression.

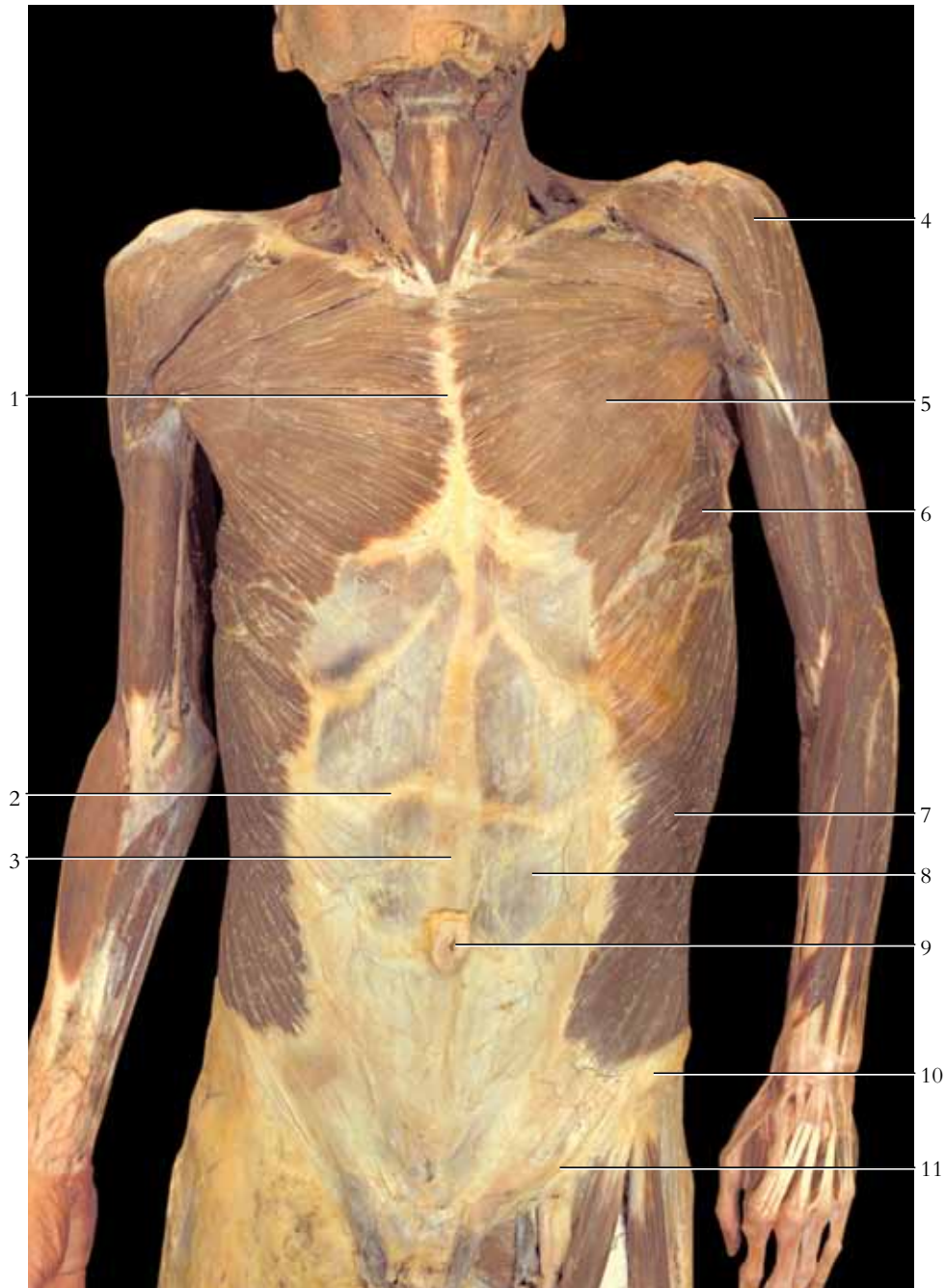
| Face Muscle                       | Origin(s)                   | Insertion(s)                         | Action                                 | Innervation |
|-----------------------------------|-----------------------------|--------------------------------------|--|-------------|
| <b>Frontalis</b>                  | Galea aponeurotica          | Skin of eyebrow                      | Wrinkles forehead and elevates eyebrow | Facial n.   |
| <b>Orbicularis oculi</b>          | Bones of orbit              | Tissue of eyelid                     | Closes eyes                            | Facial n.   |
| <b>Nasalis</b>                    | Maxilla and nasal cartilage | Aponeurosis of nose                  | Compresses nostrils                    | Facial n.   |
| <b>Orbicularis oris</b>           | Maxilla and mandible        | Lips                                 | Closes and purses lips                 | Facial n.   |
| <b>Levator labii superioris</b>   | Upper maxilla               | Orbicularis oris and skin above lips | Elevates upper lip                     | Facial n.   |
| <b>Zygomaticus</b>                | Zygomatic bone              | Superior corner of orbicularis oris  | Elevates corner of mouth               | Facial n.   |
| <b>Depressor labii inferioris</b> | Mandible                    | Inferior corner of orbicularis oris  | Depresses corner of mouth              | Facial n.   |
| <b>Mentalis</b>                   | Mandible                    | Skin of lower lip                    | Elevates and protrudes lower lip       | Facial n.   |
| <b>Buccinator</b>                 | Maxilla and mandible        | Orbicularis oris                     | Compresses cheek                       | Facial n.   |

**Table 8.2** Muscles of mastication.

| Chewing Muscle           | Origin(s)      | Insertion(s)                                  | Action                                | Innervation   |
|--------------------------|----------------|---|---------------------------------------|---------------|
| <b>Temporalis</b>        | Temporal fossa | Coronoid process of mandible                  | Elevates mandible                     | Trigeminal n. |
| <b>Masseter</b>          | Zygomatic arch | Lateral ramus of mandible                     | Elevates mandible                     | Trigeminal n. |
| <b>Medial pterygoid</b>  | Sphenoid bone  | Medial ramus of mandible                      | Elevates and laterally moves mandible | Trigeminal n. |
| <b>Lateral pterygoid</b> | Sphenoid bone  | Anterior side of condylar process of mandible | Protracts mandible                    | Trigeminal n. |

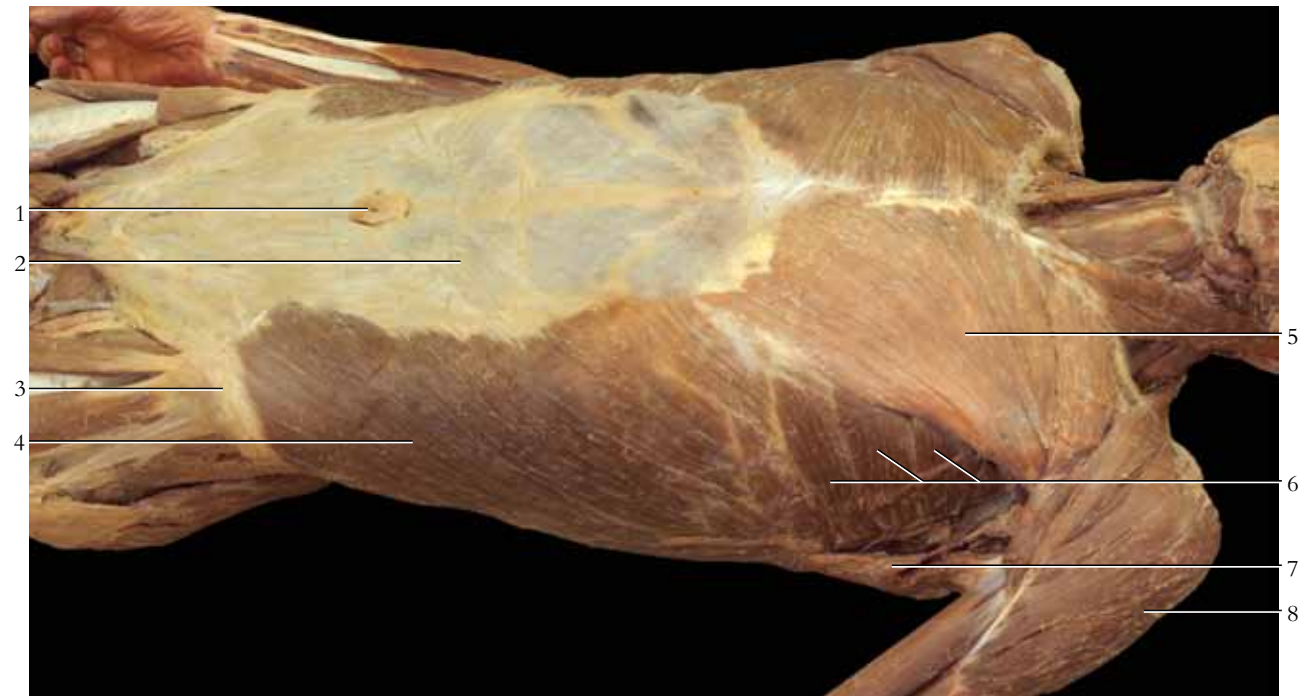
**Table 8.3** Muscles of the neck.

| Neck Muscle                | Origin(s)  | Insertion(s)                     | Action   | Innervation   |
|----------------------------|--|----------------------------------|--|---|
| <b>Sternocleidomastoid</b> | Sternum and clavicle   | Mastoid process of temporal bone | Flexes neck; rotates head to side                | Accessory n.  |
| <b>Digastric</b>           | Inferior border of mandible and mastoid process of temporal bone | Hyoid bone                       | Depresses mandible; elevates hyoid bone          | Trigeminal n. (ant. belly)<br>Facial n. (post. belly) |
| <b>Mylohyoid</b>           | Inferior border of mandible                                      | Hyoid bone and median raphe      | Elevates hyoid bone and floor of mouth           | Trigeminal n.   |
| <b>Geniohyoid</b>          | Medial surface of mandible at chin                               | Hyoid bone                       | Elevates hyoid bone                              | Spinal n. (C1)  |
| <b>Stylohyoid</b>          | Styloid process of temporal bone                                 | Hyoid bone                       | Elevates and retracts tongue                     | Facial n.   |
| <b>Sternohyoid</b>         | Manubrium  | Hyoid bone                       | Depresses hyoid bone                             | Spinal n. (C1-C3)                                     |
| <b>Sternothyroid</b>       | Manubrium  | Thyroid cartilage                | Depresses thyroid cartilage                      | Spinal n. (C1-C3)                                     |
| <b>Thyrohyoid</b>          | Thyroid cartilage  | Hyoid bone                       | Depresses hyoid bone; elevates thyroid cartilage | Spinal n. (C1)  |
| <b>Omohyoid</b>            | Superior border of scapula                                       | Hyoid bone                       | Depresses hyoid bone                             | Spinal n. (C1-C3)                                     |



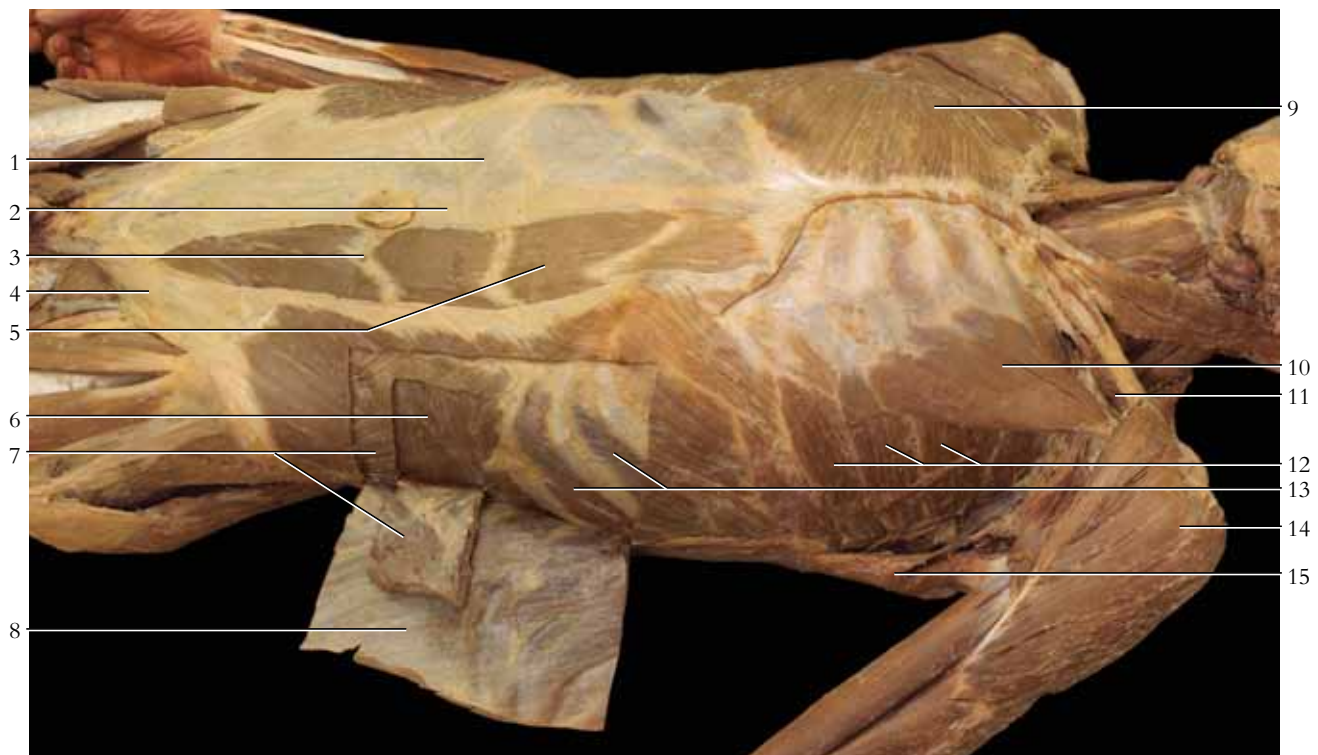
**Figure 8.12** An anterior view of the trunk.

- |                           |   |
|---------------------------|---|
| 1. Sternum                | 7. External oblique m.                          |
| 2. Tendinous intersection | 8. Rectus sheath (covering rectus abdominis m.) |
| 3. Linea alba             | 9. Umbilicus                                    |
| 4. Deltoid m.             | 10. Anterior superior iliac spine               |
| 5. Pectoralis major m.    | 11. Inguinal ligament                           |
| 6. Serratus anterior m.   |   |



**Figure 8.13** An anterolateral view of the trunk.

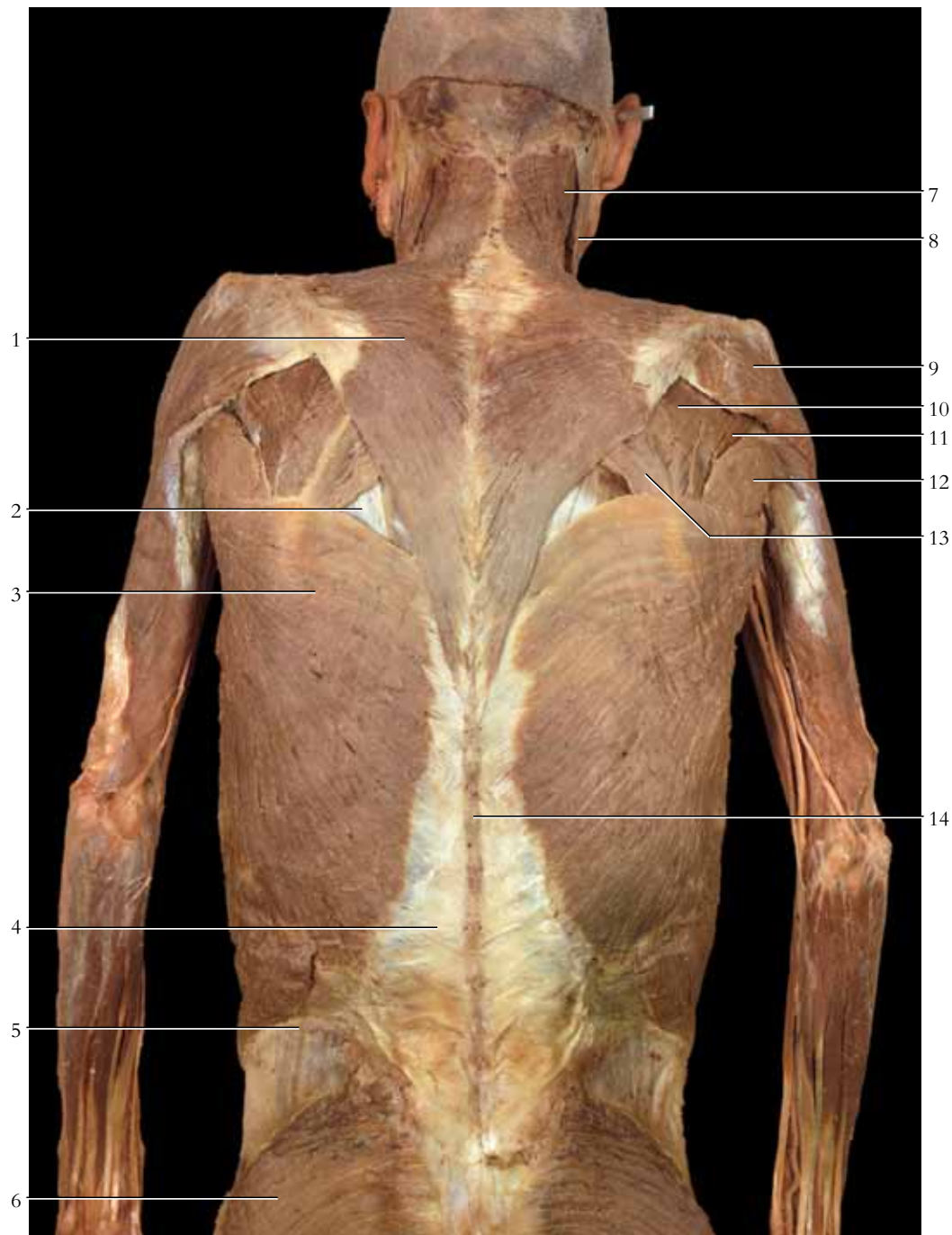
- |                                  |                          |                        |
|----------------------------------|--------------------------|------------------------|
| 1. Umbilicus                     | 4. External oblique m.   | 7. Latissimus dorsi m. |
| 2. Rectus sheath                 | 5. Pectoralis major m.   | 8. Deltoid m.          |
| 3. Anterior superior iliac spine | 6. Serratus anterior mm. |                        |



**Figure 8.14** An anterolateral view of the trunk.

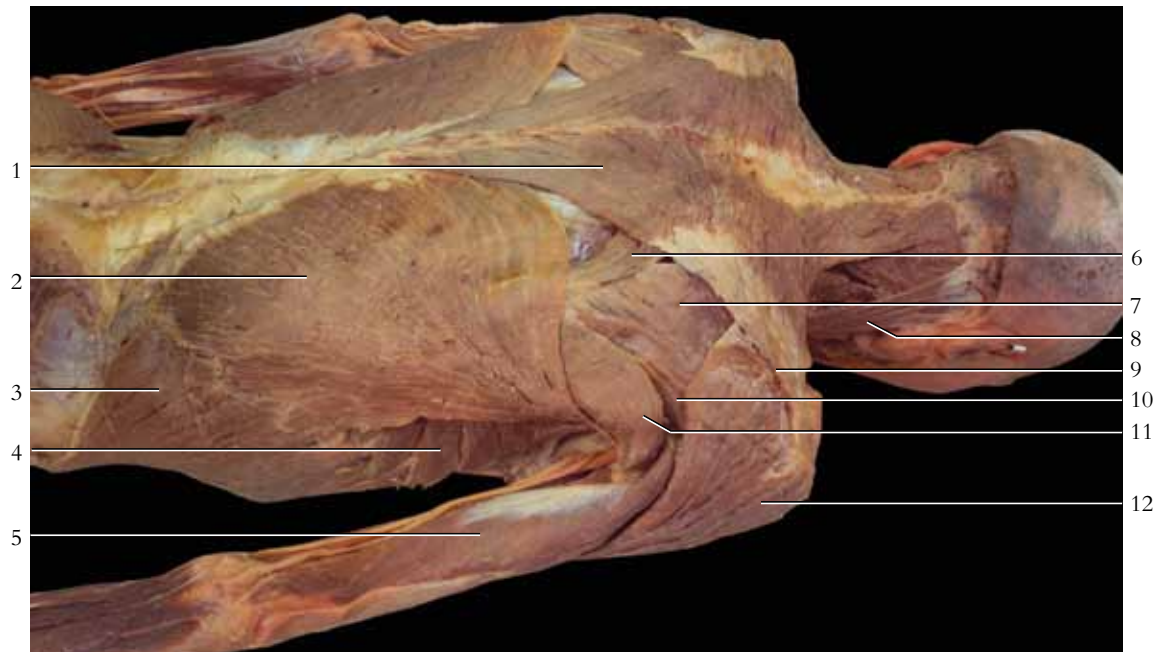
- |                           |                            |                              |
|---------------------------|----------------------------|------------------------------|
| 1. Rectus sheath          | 6. Transverse abdominis m. | 11. Subclavius m.            |
| 2. Linea alba             | 7. Internal oblique m.     | 12. Serratus anterior mm.    |
| 3. Tendinous intersection | 8. External oblique m.     | 13. External intercostal mm. |
| 4. Inguinal ligament      | 9. Pectoralis major m.     | 14. Deltoid m.               |
| 5. Rectus abdominis m.    | 10. Pectoralis minor m.    | 15. Latissimus dorsi m.      |





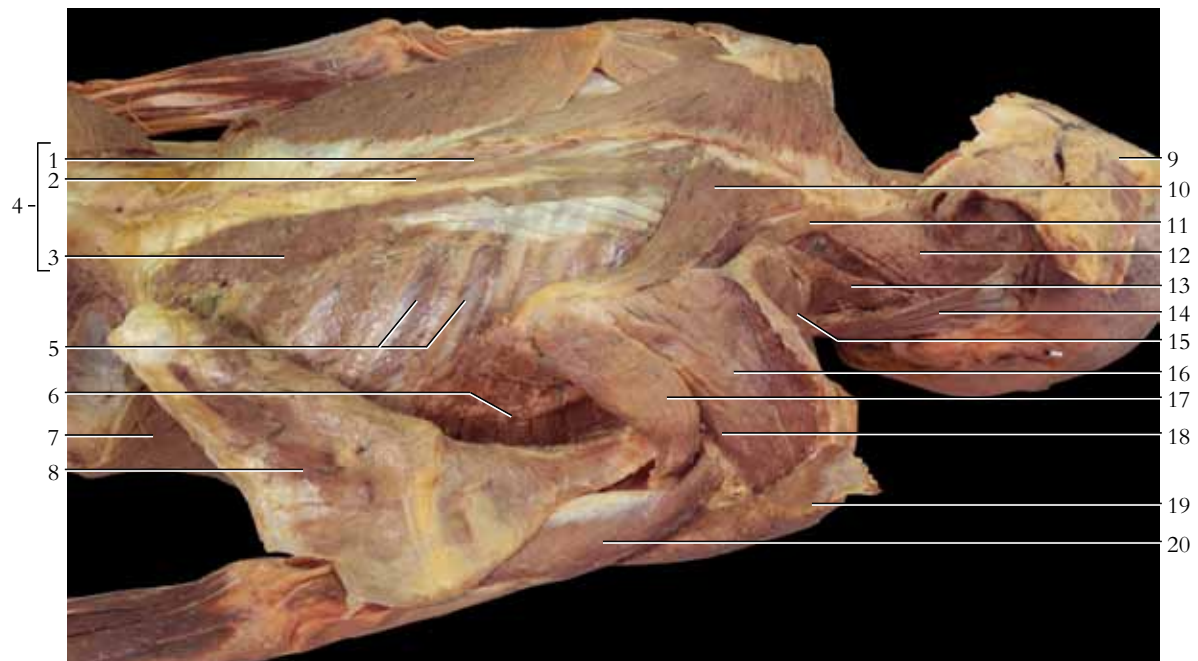
**Figure 8.15** A posterior view of the trunk.

- |                             |                           |                       |
|-----------------------------|---------------------------|-----------------------|
| 1. Trapezius m.             | 6. Gluteus maximus m.     | 11. Teres minor m.    |
| 2. Triangle of auscultation | 7. Splenius capitis m.    | 12. Teres major m.    |
| 3. Latissimus dorsi m.      | 8. Sternocleidomastoid m. | 13. Rhomboid major m. |
| 4. Thoracolumbar fascia     | 9. Deltoid m.             | 14. Vertebral column  |
| 5. Iliac crest              | 10. Infraspinatus m.      |                       |



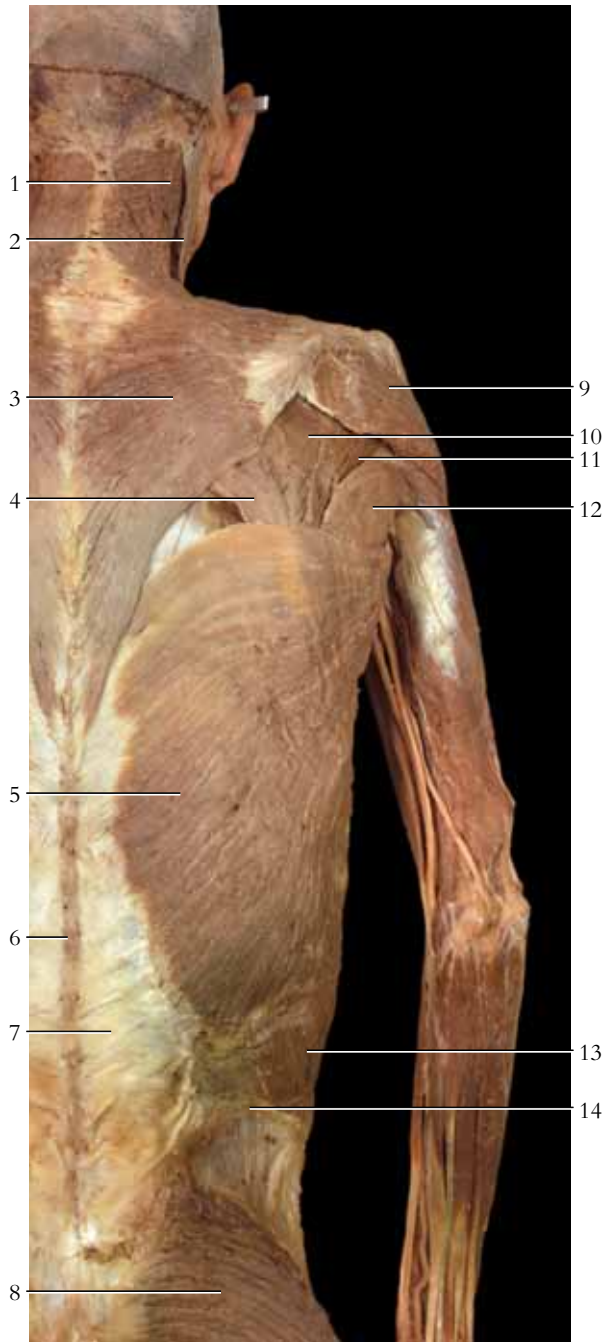
**Figure 8.16** A posterolateral view of the trunk.

- |                         |                           |                     |
|-------------------------|---------------------------|---------------------|
| 1. Trapezius m.         | 5. Triceps brachii m.     | 9. Spine of scapula |
| 2. Latissimus dorsi m.  | 6. Rhomboid major m.      | 10. Teres minor m.  |
| 3. External oblique m.  | 7. Infrapinatus m.        | 11. Teres major m.  |
| 4. Serratus anterior m. | 8. Sternocleidomastoid m. | 12. Deltoid m.      |



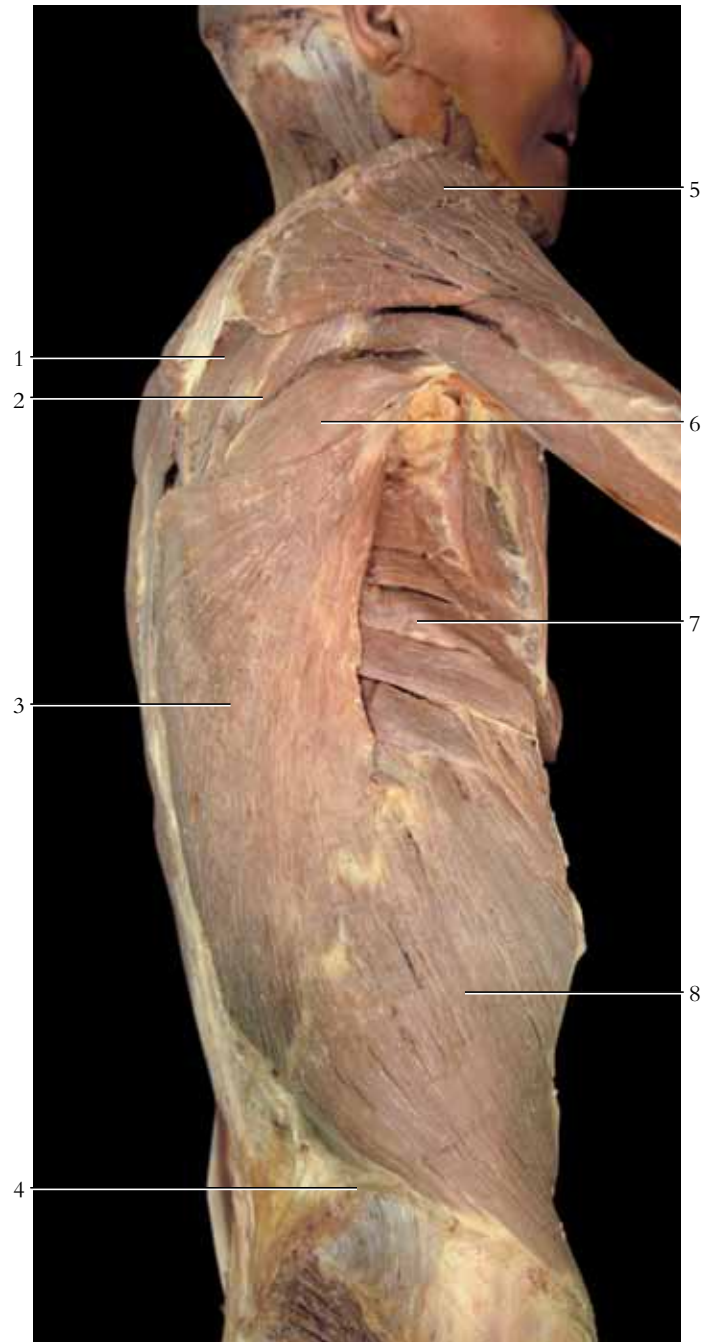
**Figure 8.17** A posterolateral view of the deep muscles of the trunk.

- |                                |                            |                        |
|--------------------------------|----------------------------|------------------------|
| 1. Spinalis m. (cut)           | 9. Trapezius m.            | 16. Infrapinatus m.    |
| 2. Longissimus m.              | (cut and reflected)        | 17. Teres major m.     |
| 3. Iliocostalis m.             | 10. Rhomboid major m.      | 18. Teres minor m.     |
| 4. Erector spinae muscle group | 11. Rhomboid minor m.      | 19. Deltoid m.         |
| 5. External intercostal mm.    | 12. Splenius capitis m.    | (cut and reflected)    |
| 6. Serratus anterior m.        | 13. Levator scapulae m.    | 20. Triceps brachii m. |
| 7. External oblique m.         | 14. Sternocleidomastoid m. |                        |
| 8. Latissimus dorsi m.         | 15. Supraspinatus m.       |                        |
| (cut and reflected)            |                            |                        |



**Figure 8.18** A posterior view of the trunk.

- |                           |                         |
|---------------------------|-------------------------|
| 1. Splenius capitis m.    | 8. Gluteus maximus m.   |
| 2. Sternocleidomastoid m. | 9. Deltoid m.           |
| 3. Trapezius m.           | 10. Infraspinatus m.    |
| 4. Rhomboid major m.      | 11. Teres minor m.      |
| 5. Latissimus dorsi m.    | 12. Teres major m.      |
| 6. Vertebral column       | 13. External oblique m. |
| 7. Thoracolumbar fascia   | 14. Iliac crest         |



**Figure 8.19** A lateral view of the trunk.

- |                        |                         |
|------------------------|-------------------------|
| 1. Infraspinatus m.    | 5. Deltoid m.           |
| 2. Teres minor m.      | 6. Teres major m.       |
| 3. Latissimus dorsi m. | 7. Serratus anterior m. |
| 4. Iliac crest         | 8. External oblique m.  |



**Table 8.4** Muscles of the abdominal wall.

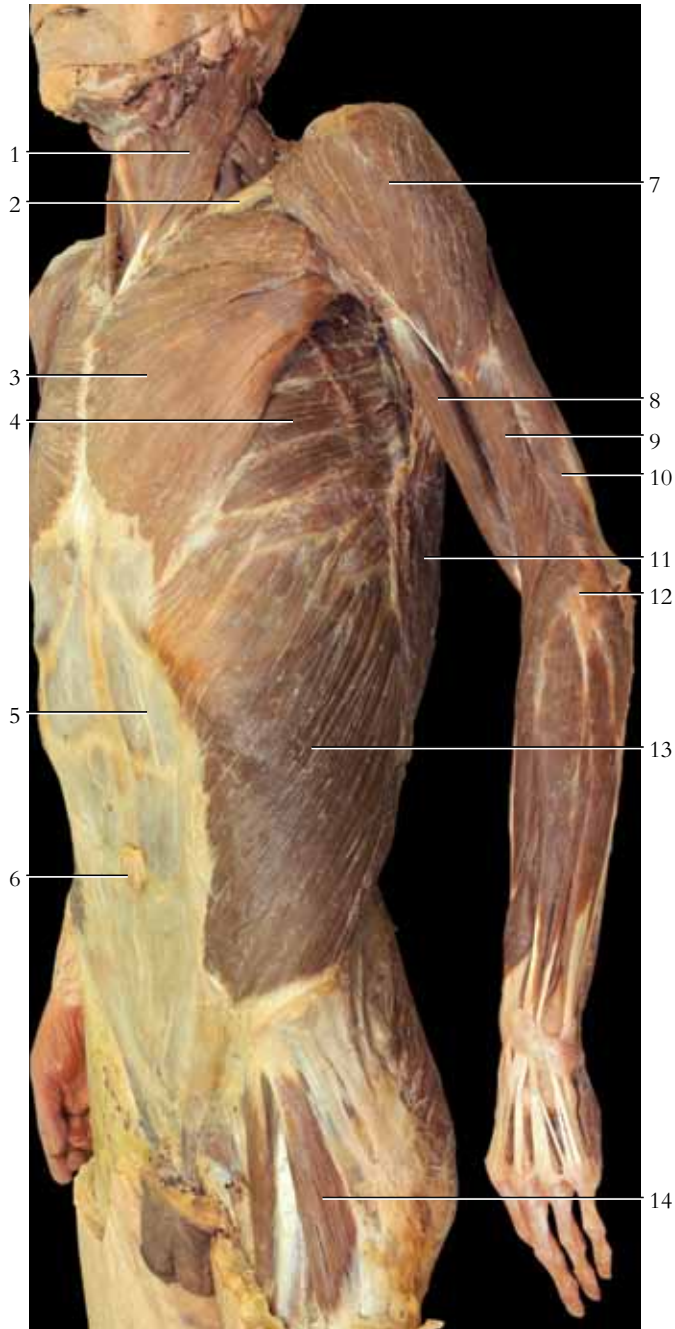
| Abdominal Muscle                  | Origin(s)  | Insertion(s)   | Action                               | Innervation  |
|-----------------------------------|--|--|--------------------------------------|--|
| <b>External abdominal oblique</b> | Lower eight ribs   | Iliac crest and linea alba                                     | Compresses abdomen; lateral rotation | Intercostal nn.<br>Iliohypogastric n.<br>Ilioinguinal n. |
| <b>Internal abdominal oblique</b> | Iliac crest, lumbodorsal fascia, inguinal ligament                                     | Linea alba and costal cartilages of last three or four ribs    | Compresses abdomen; lateral rotation | Intercostal nn.<br>Iliohypogastric n.<br>Ilioinguinal n. |
| <b>Transversus abdominis</b>      | Iliac crest, lumbodorsal fascia, inguinal ligament, costal cartilages of last six ribs | Xiphoid process, linea alba, pubis                             | Compresses abdomen                   | Intercostal nn.<br>Iliohypogastric n.<br>Ilioinguinal n. |
| <b>Rectus abdominis</b>           | Pubic crest and symphysis pubis  | Xiphoid process and costal cartilages of fifth to seventh ribs | Flexes vertebral column              | Intercostal nn.  |

**Table 8.5** Muscles that act on the pectoral girdle.

| Pectoral Muscle          | Origin(s)  | Insertion(s)                            | Action   | Innervation                     |
|--------------------------|--|---|--|---------------------------------|
| <b>Serratus anterior</b> | Upper eight or nine ribs                                     | Anterior medial border of scapula       | Pulls scapula forward and upward   | Long thoracic n.                |
| <b>Pectoralis minor</b>  | Sternal ends of third, fourth, and fifth ribs                | Coracoid process of scapula             | Pulls scapula forward and downward   | Medial and lateral pectoral nn. |
| <b>Subclavius</b>        | First rib  | Subclavian groove of clavical           | Depresses clavicle   | Spinal nn. C5, C6               |
| <b>Trapezius</b>         | Occipital bone and spines of cervical and thoracic vertebrae | Clavicle, acromion and spine of scapula | Elevates, depresses, and adducts scapula; hyperextends neck; braces shoulder | Accessory n.                    |
| <b>Levator scapulae</b>  | First to fourth cervical vertebrae                           | Superior border of scapula              | Elevates scapula   | Dorsal scapular n.              |
| <b>Rhomboid major</b>    | Spines of second to fifth thoracic vertebrae                 | Medial border of scapula                | Elevates and adducts scapula   | Dorsal scapular n.              |
| <b>Rhomboid minor</b>    | Seventh cervical and first thoracic vertebrae                | Medial border of scapula                | Elevates and adducts scapula   | Dorsal scapular n.              |

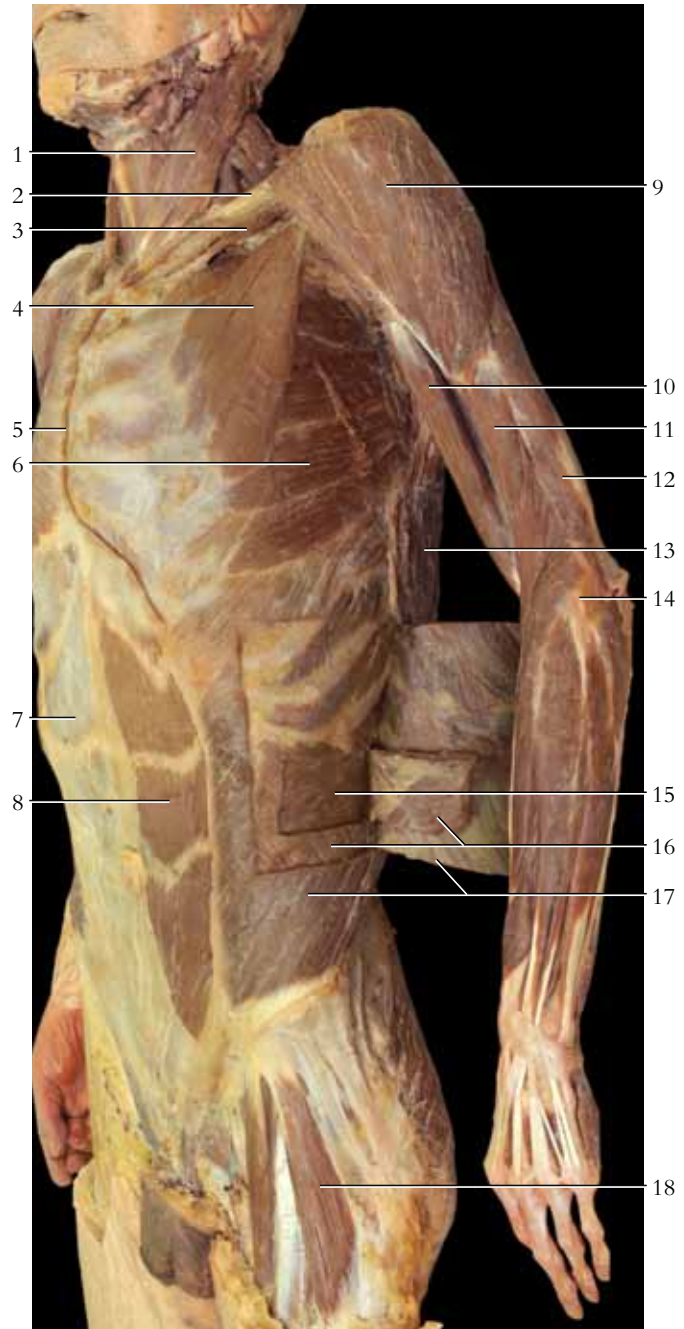
**Table 8.6** Muscles of the vertebral column.

| Spinal Muscle             | Origin(s)                              | Insertion(s)  | Action   | Innervation                             |
|---------------------------|--|---|--|---|
| <b>Quadratus lumborum</b> | Iliac crest and lower lumbar vertebrae | Twelfth rib and upper four lumbar vertebrae             | Extends lumbar region; flexes vertebral column laterally | Intercostal n. T12 and Lumbar nn. L2-L4 |
| <b>Erector spinae</b>     |  |   |  |   |
| Iliocostalis lumborum     | Crest of ilium                         | Lower six ribs  | Extends lumbar region                                    | Post. rami of lumbar nn.                |
| Iliocostalis thoracis     | Lower six ribs                         | Upper six ribs  | Extends thoracic region                                  | Post. rami of thoracic nn.              |
| Iliocostalis cervicis     | Angles of third–sixth ribs             | Transverse processes of fourth–sixth cervical vertebrae | Extends cervical region                                  | Post. rami of cervical nn.              |



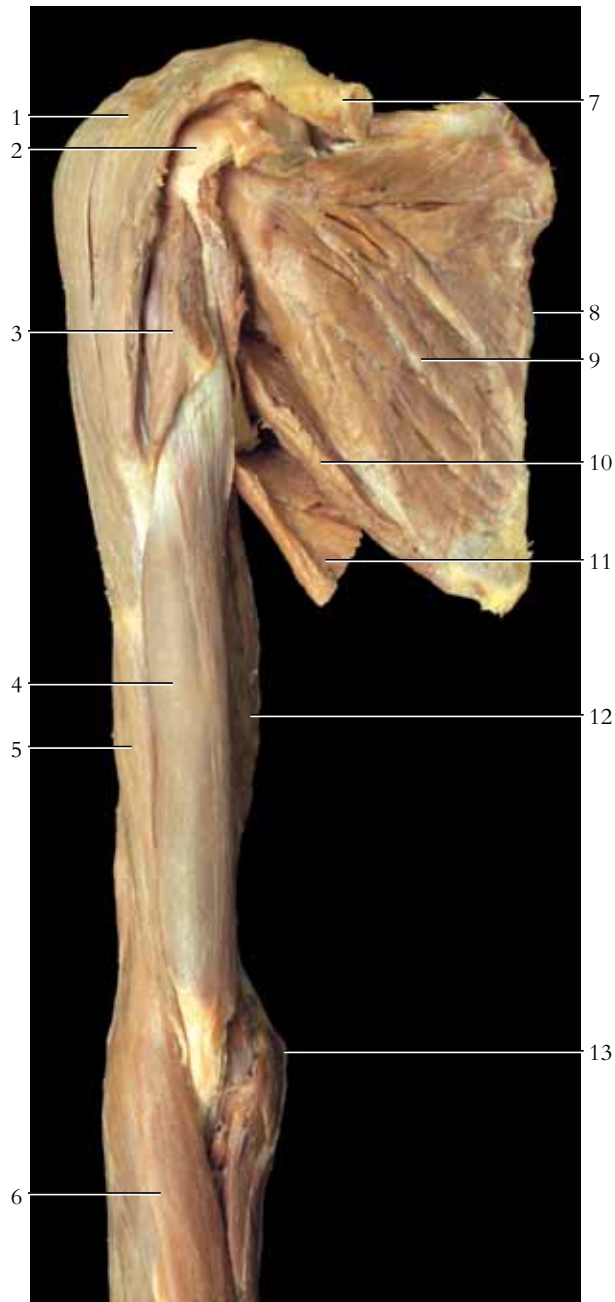
**Figure 8.20** An anterolateral view of the trunk and arm.

- |                           |                            |
|---------------------------|----------------------------|
| 1. Sternocleidomastoid m. | 8. Biceps brachii m.       |
| 2. Clavicle               | 9. Brachialis m.           |
| 3. Pectoralis major m.    | 10. Triceps brachii m.     |
| 4. Serratus anterior m.   | 11. Latissimus dorsi m.    |
| 5. Rectus sheath          | 12. Lateral epicondyle     |
| 6. Umbilicus              | 13. External oblique m.    |
| 7. Deltoid m.             | 14. Tensor fascia latae m. |



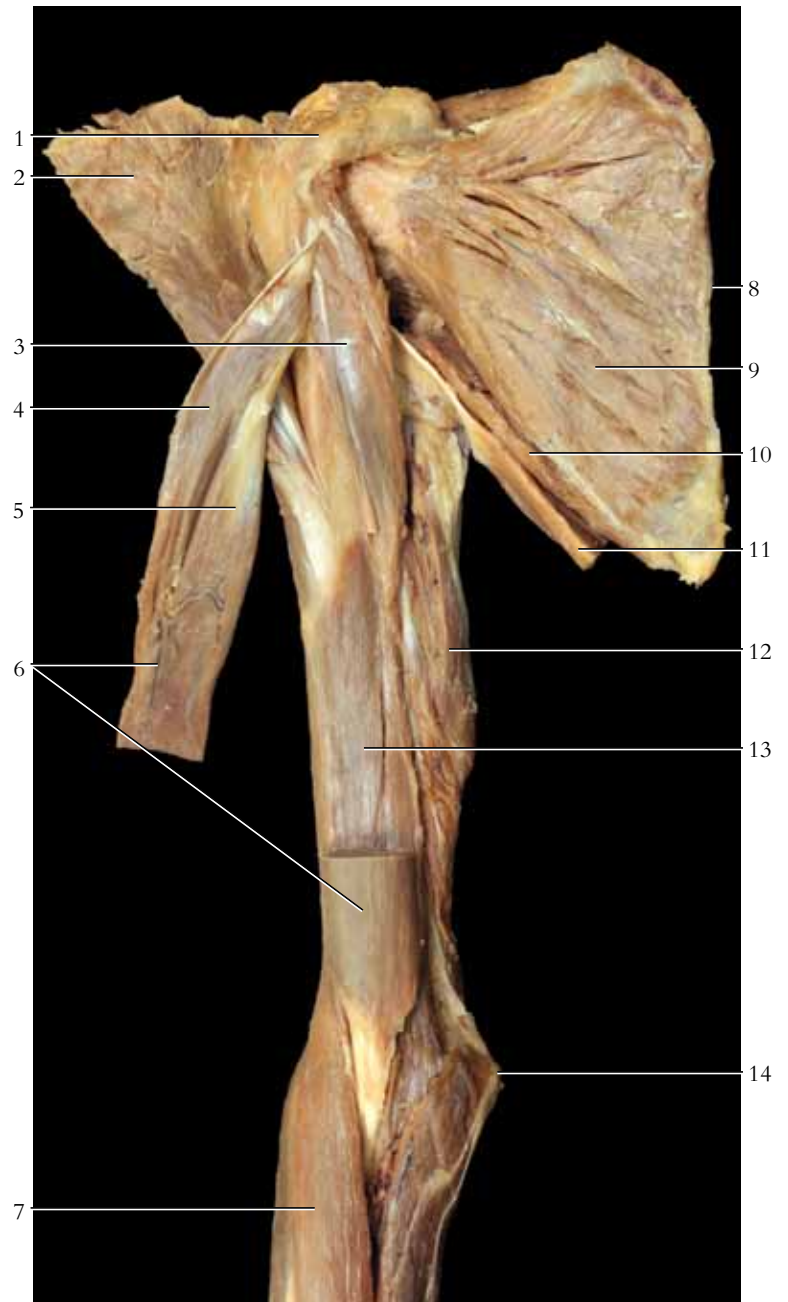
**Figure 8.21** An anterolateral view of the trunk and arm.

- |                              |                                       |
|------------------------------|---------------------------------------|
| 1. Sternocleidomastoid m.    | 11. Brachialis m.                     |
| 2. Clavicle                  | 12. Triceps brachii m.                |
| 3. Subclavius m.             | 13. Latissimus dorsi m.               |
| 4. Pectoralis minor m.       | 14. Lateral epicondyle                |
| 5. Pectoralis major m. (cut) | 15. Transverse abdominis m.           |
| 6. Serratus anterior m.      | 16. Internal oblique m. (section cut) |
| 7. Rectus sheath             | 17. External oblique m. (section cut) |
| 8. Rectus abdominis m.       | 18. Tensor fascia latae m.            |
| 9. Deltoid m.                |                                       |
| 10. Biceps brachii m.        |                                       |



**Figure 8.22** An anterior view of the right upper arm and shoulder (disarticulated).

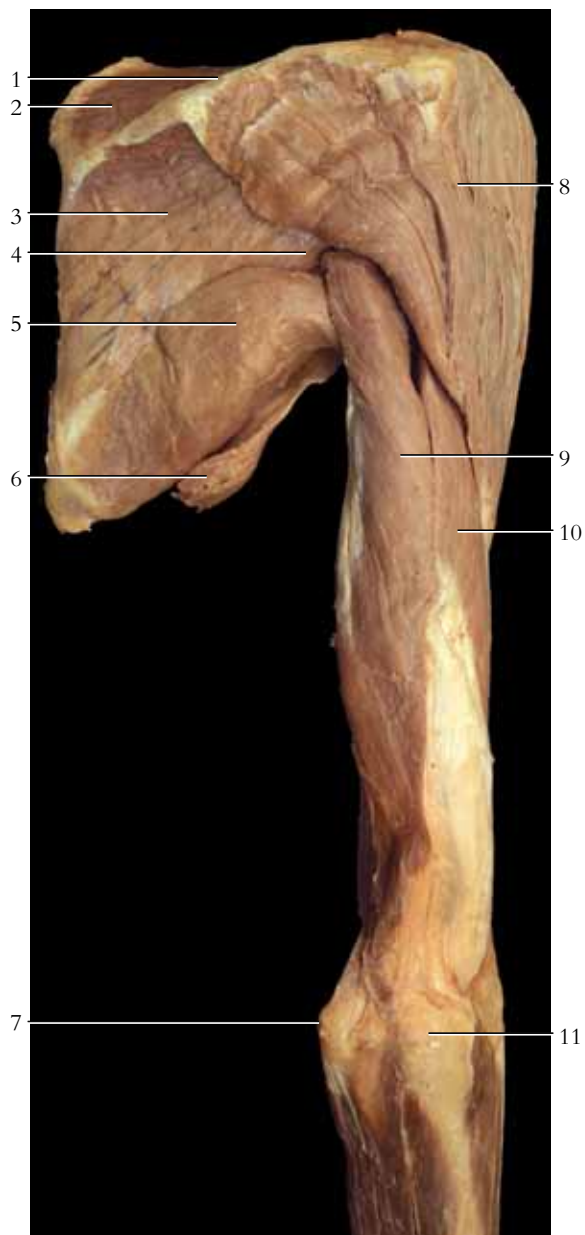
- |                                |                                  |
|--------------------------------|----------------------------------|
| 1. Deltoid m.                  | 9. Subscapularis m.              |
| 2. Coracoid process of scapula | 10. Teres major m.               |
| 3. Pectoralis major m. (cut)   | 11. Latissimus dorsi m. (cut)    |
| 4. Biceps brachii m.           | 12. Triceps brachii m.           |
| 5. Brachialis m.               | 13. Medial epicondyle of humerus |
| 6. Brachioradialis m.          |                                  |
| 7. Clavicle (cut)              |                                  |
| 8. Medial margin of scapula    |                                  |



**Figure 8.23** An anterior view of the right upper arm and shoulder (disarticulated).

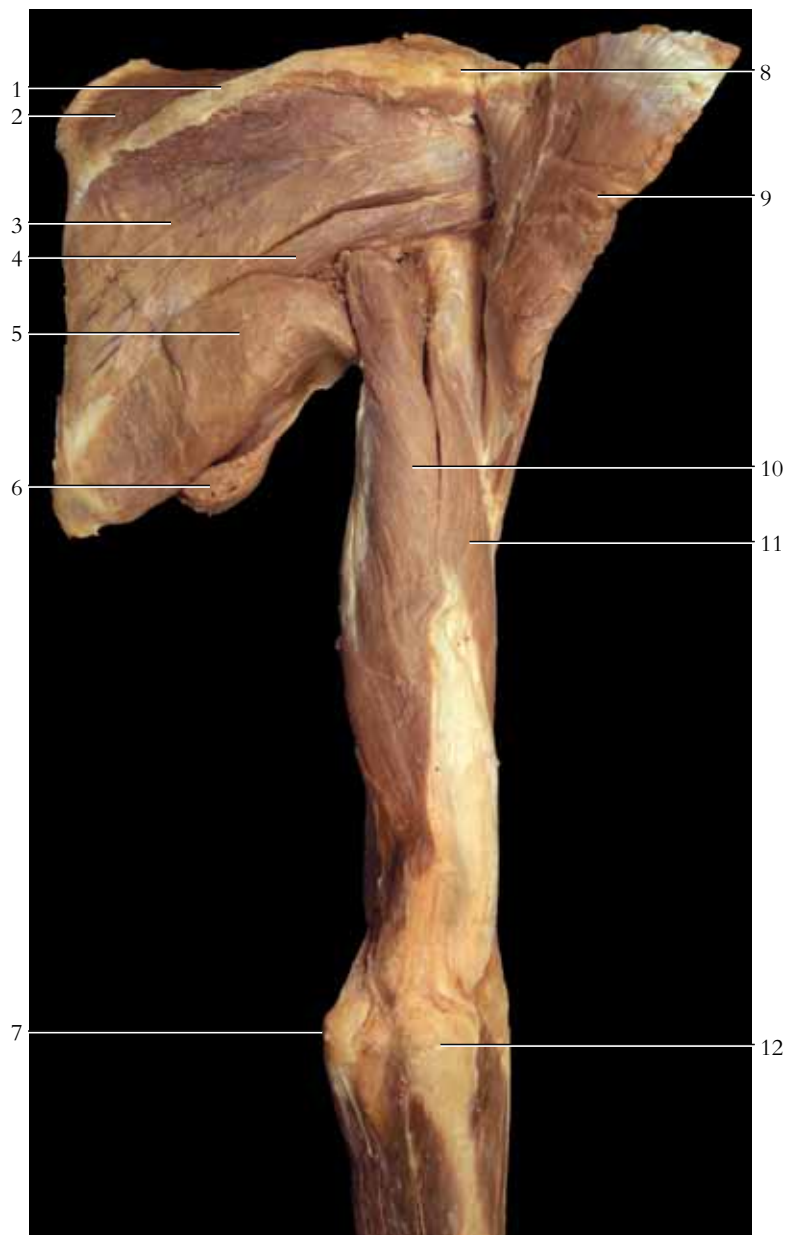
- |  |                                  |
|--|----------------------------------|
| 1. Coracoid process of scapula           | 8. Medial margin of scapula      |
| 2. Deltoid m. (cut and reflected)        | 9. Subscapularis m.              |
| 3. Coracobrachialis m.                   | 10. Teres major m.               |
| 4. Short head of biceps brachii m.       | 11. Latissimus dorsi m. (cut)    |
| 5. Long head of biceps brachii m.        | 12. Triceps brachii m.           |
| 6. Biceps brachii m. (cut and reflected) | 13. Brachialis m.                |
| 7. Brachioradialis m.                    | 14. Medial epicondyle of humerus |





**Figure 8.24** A posterior view of the right upper arm and shoulder (disarticulated).

- |                                 |                                       |
|---------------------------------|---------------------------------------|
| 1. Spine of scapula             | 8. Deltoid m.                         |
| 2. Supraspinatus m.             | 9. Triceps brachii m. (long head)     |
| 3. Infraspinatus m.             | 10. Triceps brachii m. (lateral head) |
| 4. Teres minor m.               | 11. Olecranon process of ulna         |
| 5. Teres major m.               |                                       |
| 6. Latissimus dorsi m. (cut)    |                                       |
| 7. Medial epicondyle of humerus |                                       |



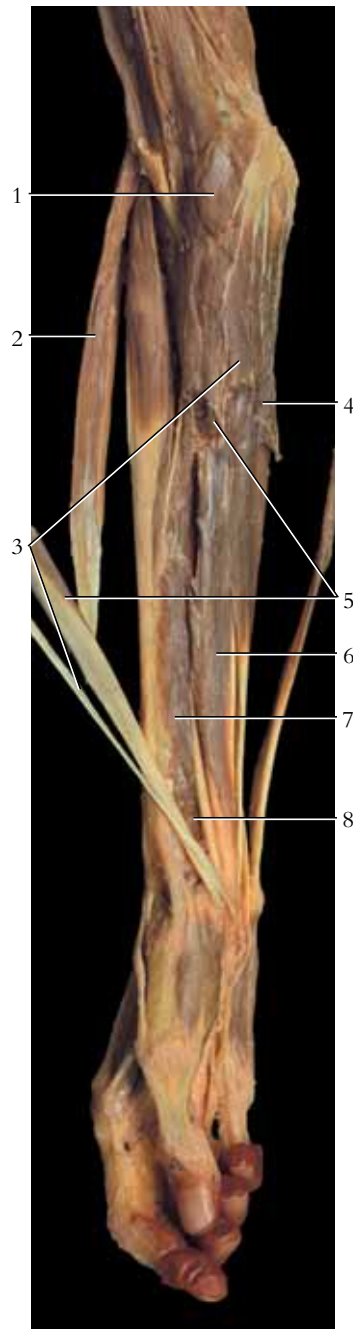
**Figure 8.25** A posterior deep view of the right upper arm and shoulder (disarticulated).

- |                                 |                                       |
|---------------------------------|---------------------------------------|
| 1. Spine of scapula             | 9. Deltoid m. (cut and reflected)     |
| 2. Supraspinatus m.             | 10. Triceps brachii m. (long head)    |
| 3. Infraspinatus m.             | 11. Triceps brachii m. (lateral head) |
| 4. Teres minor m.               | 12. Olecranon process of ulna         |
| 5. Teres major m.               |                                       |
| 6. Latissimus dorsi m. (cut)    |                                       |
| 7. Medial epicondyle of humerus |                                       |
| 8. Acromion                     |                                       |



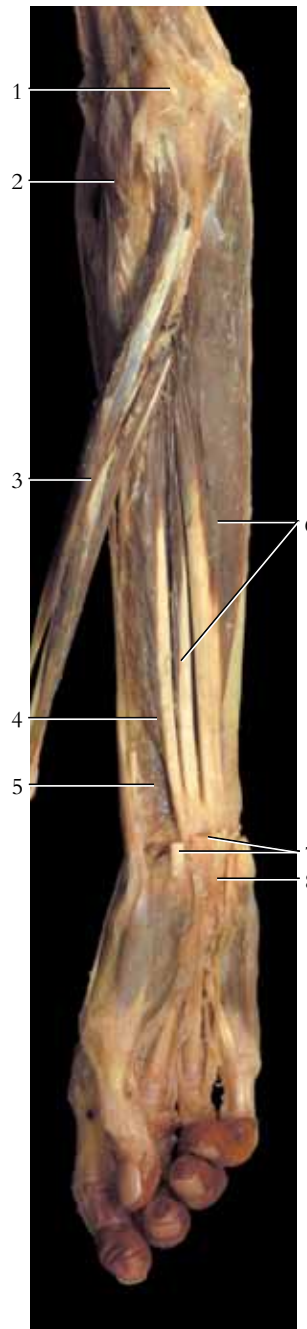
**Figure 8.26** An anterior view of the superficial muscles of the right forearm.

1. Pronator teres m.
2. Brachioradialis m.
3. Flexor carpi radialis m.
4. Flexor pollicis longus m.
5. Palmaris longus m.
6. Flexor carpi ulnaris m.



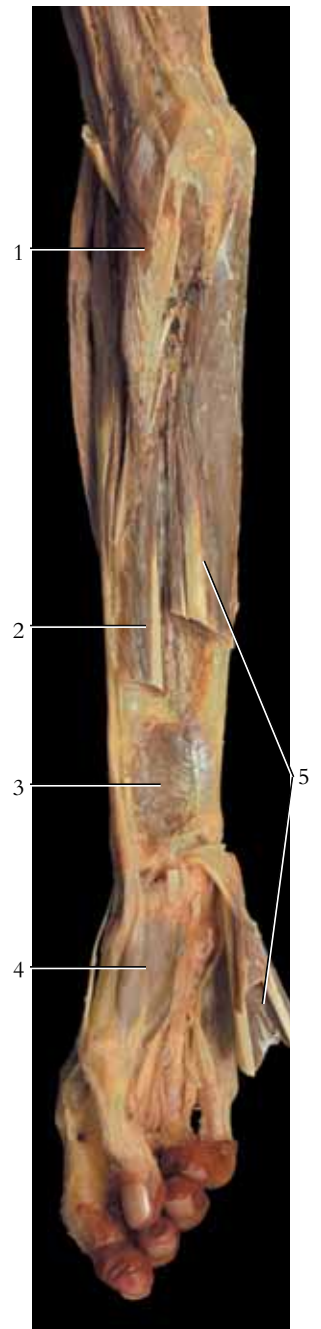
**Figure 8.27** An anterior view of the muscles of the right forearm.

1. Pronator teres m.
2. Brachioradialis m. (cut and reflected)
3. Palmaris longus m. (cut and reflected)
4. Flexor carpi ulnaris m. (cut)
5. Flexor carpi radialis m. (cut and reflected)
6. Flexor digitorum superficialis m.
7. Flexor pollicis longus m.
8. Pronator quadratus m.



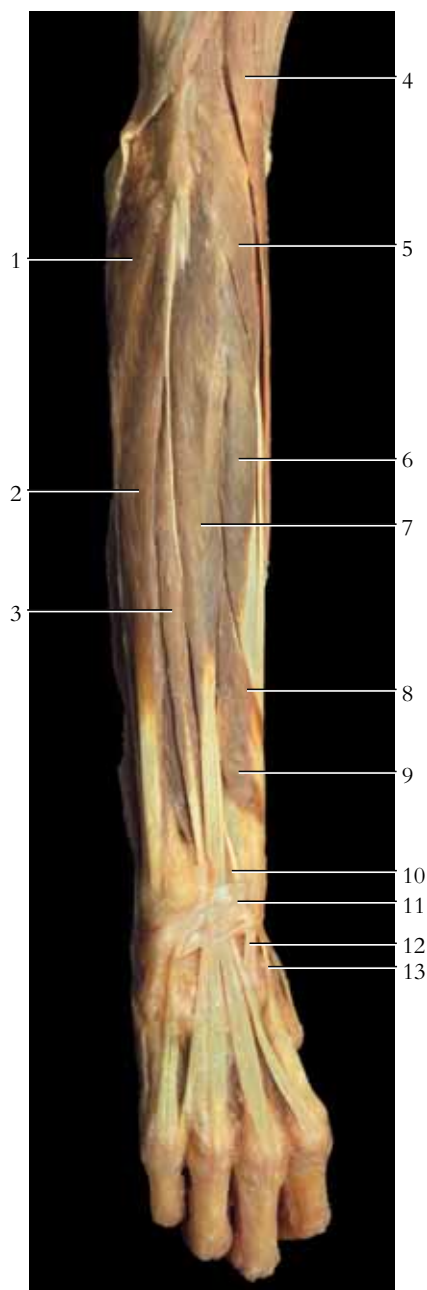
**Figure 8.28** An anterior view of the deep muscles of the right forearm.

1. Medial epicondyle
2. Pronator teres m.
3. Flexor digitorum superficialis m. (cut and reflected)
4. Flexor pollicis longus m.
5. Pronator quadratus m.
6. Flexor digitorum profundus m.
7. Tendons of flexor carpi radialis and flexor digitorum superficialis mm. (cut)
8. Carpal tunnel



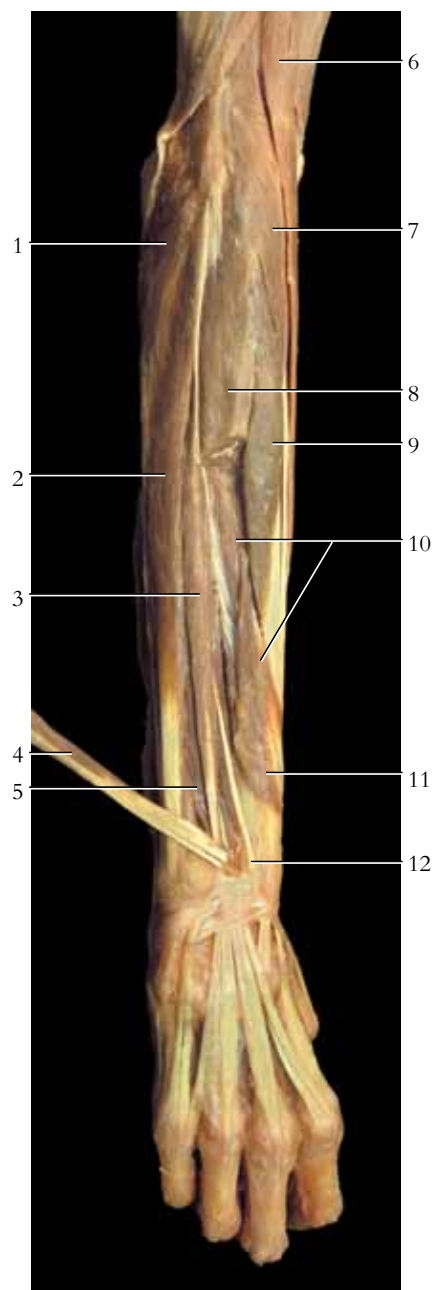
**Figure 8.29** An anterior view of the deep muscles of the right forearm.

1. Pronator teres m.
2. Flexor pollicis longus m. (cut)
3. Pronator quadratus m.
4. Thenar mm.
5. Flexor digitorum superficialis and profundus mm. (cut and reflected)



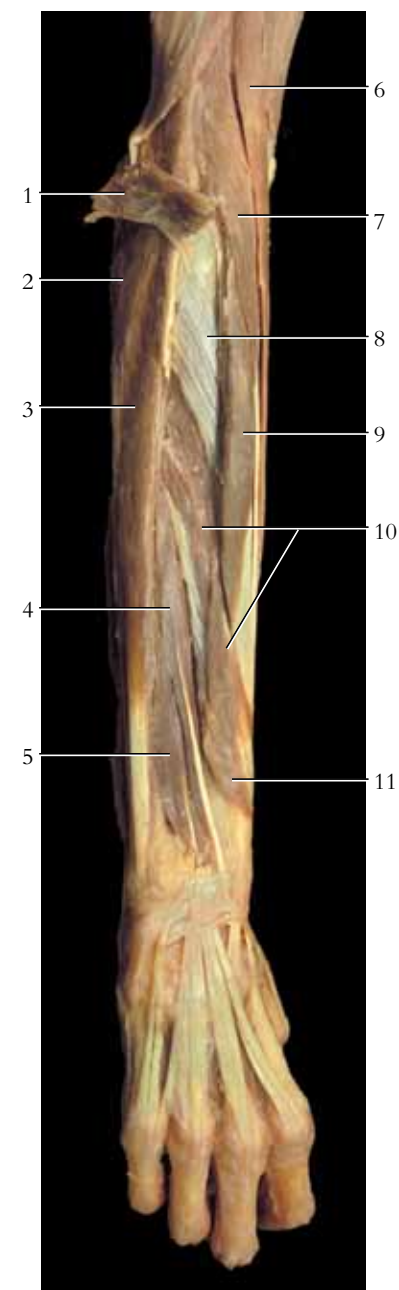
**Figure 8.30** A posterior view of the superficial muscles of the right forearm.

1. Anconeus m.
2. Extensor carpi ulnaris m.
3. Extensor digiti minimi m.
4. Brachioradialis m.
5. Extensor carpi radialis longus m.
6. Extensor carpi radialis brevis m.
7. Extensor digitorum m.
8. Abductor pollicis longus m.
9. Extensor pollicis brevis m.
10. Extensor pollicis longus m.
11. Extensor retinaculum
12. Tendon of extensor carpi radialis brevis
13. Tendon of extensor carpi radialis longus



**Figure 8.31** A posterior view of the muscles of the right forearm.

1. Anconeus m.
2. Extensor carpi ulnaris m.
3. Extensor digiti minimi m.
4. Extensor digitorum m. (cut and reflected)
5. Extensor indicis m.
6. Brachioradialis m.
7. Extensor carpi radialis longus m.
8. Extensor digitorum m. (cut)
9. Extensor carpi radialis brevis m.
10. Abductor pollicis longus m.
11. Extensor pollicis brevis m.
12. Tendon of extensor pollicis longus



**Figure 8.32** A posterior view of the deep muscles of the right forearm.

1. Extensor digitorum m. (cut and reflected)
2. Anconeus m.
3. Extensor carpi ulnaris m.
4. Extensor pollicis longus m.
5. Extensor indicis m.
6. Brachioradialis m.
7. Extensor carpi radialis longus m.
8. Supinator m.
9. Extensor carpi radialis brevis m.
10. Abductor pollicis longus m.
11. Extensor pollicis brevis m.

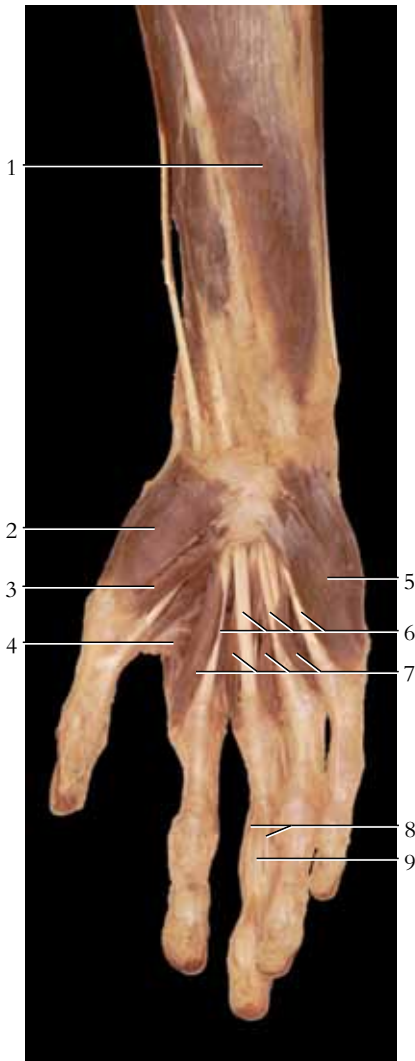


**Table 8.7** Muscles of the brachium (upper arm).

| Axial or Scapular Muscle | Origin(s)  | Insertion(s)                      | Action  | Innervation                     |
|--------------------------|--|-----------------------------------|---|---------------------------------|
| <b>Pectoralis major</b>  | Clavicle, sternum, costal cartilages of second to sixth ribs       | Greater tubercle of humerus       | Flexes, adducts, and rotates shoulder joint medially                          | Medial and lateral pectoral nn. |
| <b>Latissimus dorsi</b>  | Spines of sacral, lumbar, and lower thoracic vertebrae; lower ribs | Intertubercular groove of humerus | Extends, adducts, and rotates shoulder joint medially; adducts shoulder joint | Thoracodorsal n.                |
| <b>Deltoid</b>           | Clavicle, acromion and spine of scapula                            | Deltoid tuberosity of humerus     | Abducts, extends, or flexes shoulder joint                                    | Axillary n.                     |
| <b>Supraspinatus</b>     | Supraspinous fossa of scapula                                      | Greater tubercle of humerus       | Abducts shoulder joint  | Suprascapular n.                |
| <b>Infraspinatus</b>     | Infraspinous fossa of scapula                                      | Greater tubercle of humerus       | Rotates shoulder joint laterally  | Suprascapular n.                |
| <b>Teres major</b>       | Inferior angle and lateral border of scapula                       | Intertubercular groove of humerus | Extends, and rotates shoulder joint medially                                  | Lower subscapular n.            |
| <b>Teres minor</b>       | Lateral border of scapula  | Greater tubercle of humerus       | Rotates shoulder joint laterally  | Axillary n.                     |
| <b>Subscapularis</b>     | Subscapular fossa  | Lesser tubercle of humerus        | Rotates shoulder joint medially   | Subscapular n.                  |
| <b>Coracobrachialis</b>  | Coracoid process of scapula  | Body of humerus                   | Flexes and adducts shoulder joint   | Musculocutaneous n.             |

**Table 8.8** Muscles of the antebrachium (forearm).

| Brachial Muscle        | Origin(s)  | Insertion(s)                          | Action   | Innervation         |
|------------------------|--|---------------------------------------|--|---------------------|
| <b>Biceps brachii</b>  | Coracoid process and tuberosity above glenoid fossa                    | Radial tuberosity                     | Flexes elbow joint; supinates forearm and hand at radioulnar joint | Musculocutaneous n. |
| <b>Brachialis</b>      | Anterior body of humerus   | Tuberosity of ulna                    | Flexes elbow joint   | Musculocutaneous n. |
| <b>Brachioradialis</b> | Lateral supracondylar ridge of humerus                                 | Proximal to styloid process of radius | Flexes elbow joint   | Radial n.           |
| <b>Triceps brachii</b> | Tuberosity below glenoid fossa: lateral and medial surfaces of humerus | Olecranon of ulna                     | Extends elbow joint  | Radial n.           |
| <b>Anconeus</b>        | Lateral epicondyle of humerus  | Olecranon of ulna                     | Extends elbow joint  | Radial n.           |



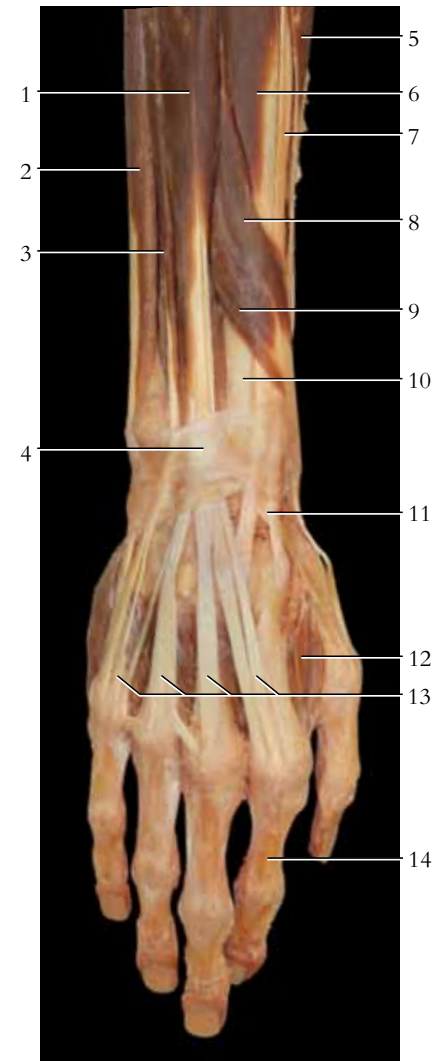
**Figure 8.33** An anterior view of right hand.

1. Flexor carpi ulnaris m.
2. Abductor pollicis brevis m.
3. Flexor pollicis brevis m.
4. Adductor pollicis m.
5. Hypothenar mm.
6. Tendons of flexor digitorum superficialis
7. Lumbrical mm.
8. Flexor digitorum superficialis tendon (bifurcated for insertion)
9. Tendon of flexor digitorum profundus



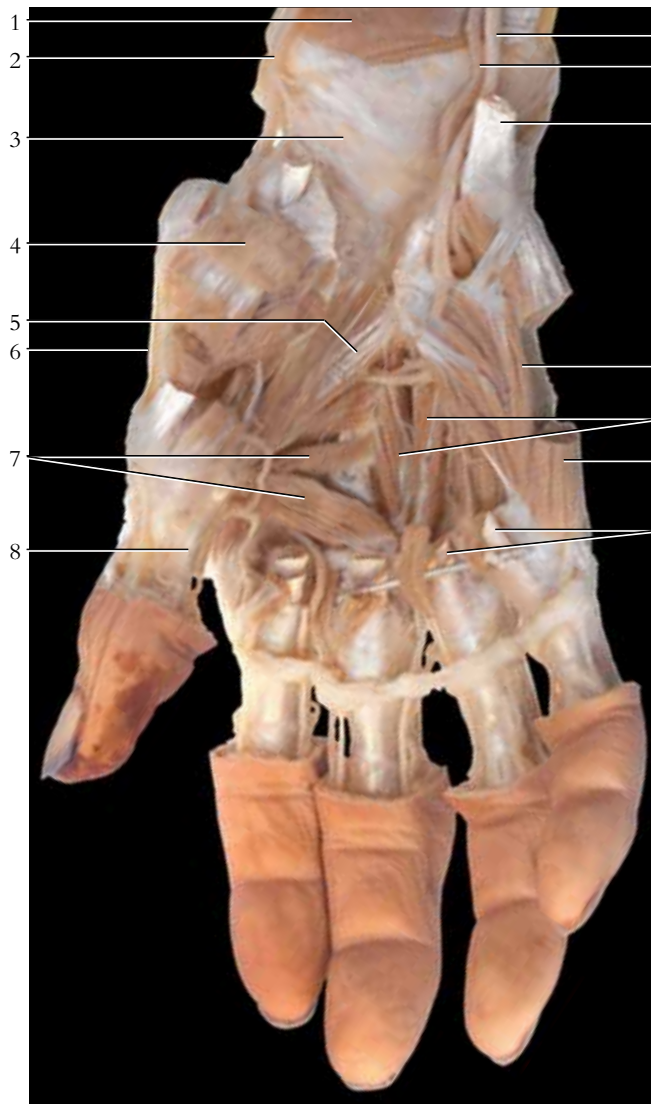
**Figure 8.34** A lateral view of right hand.

1. Extensor carpi radialis longus m.
2. Tendon of extensor carpi radialis brevis m.
3. Abductor pollicis longus m.
4. Extensor pollicis brevis m.
5. Anatomical snuff box
6. Tendon of extensor pollicis longus m.
7. First dorsal interosseus m.



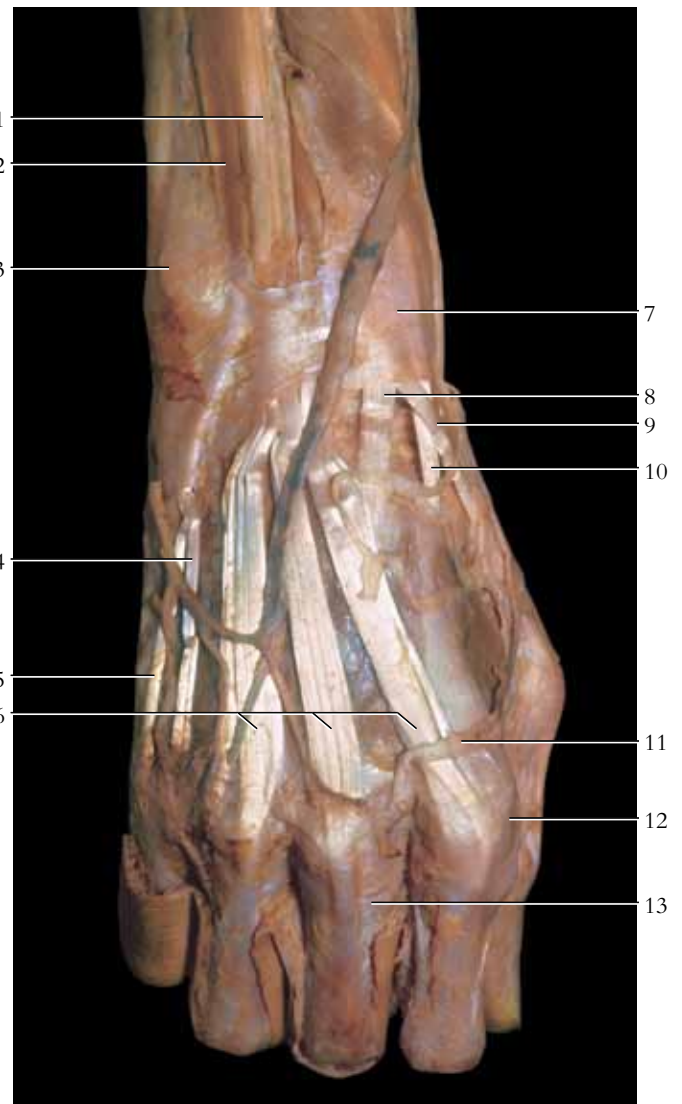
**Figure 8.35** A posterior view of right hand.

1. Extensor digitorum m.
2. Extensor carpi ulnaris m.
3. Extensor digiti minimi m.
4. Extensor retinaculum
5. Brachioradialis m.
6. Extensor carpi radialis brevis m.
7. Tendon of extensor carpi radialis longus m.
8. Abductor pollicis longus m.
9. Extensor pollicis brevis m.
10. Radius
11. Tendon of extensor pollicis longus m.
12. First dorsal interosseus m.
13. Extensor digitorum tendons
14. Extensor expansion



**Figure 8.36** An anterior view of right hand.

1. Pronator quadratus m.
2. Radial artery
3. Flexor synovial sheath
4. Flexor pollicis brevis m.
5. Opponens pollicis m.
6. Tendon of extensor pollicis brevis m.
7. Adductor pollicis mm.
8. Tendon of flexor pollicis longus m.
9. Ulnar nerve
10. Ulnar artery
11. Tendon of flexor carpi ulnaris m.
12. Opponens digiti minimi m.
13. Lumbrical mm.
14. Abductor digiti minimi and flexor digiti minimi mm. (cut)
15. Tendons of deep digital flexor m. (cut)



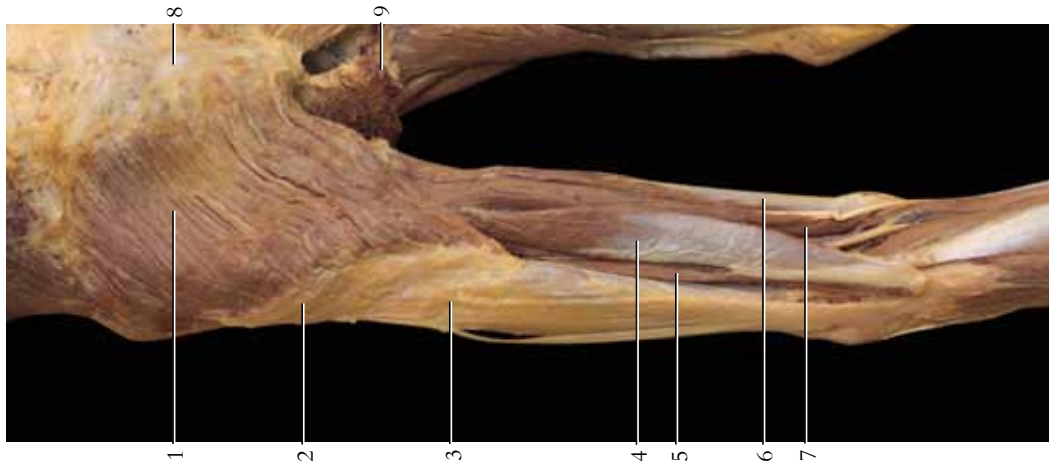
**Figure 8.37** A posterior view of right hand showing superficial structures.

1. Tendon of extensor digitorum m.
2. Extensor digiti minimi m.
3. Styloid process of ulna
4. Tendon of extensor digitorum m.
5. Tendon of extensor digiti minimi m.
6. Tendons of extensor digitorum mm.
7. Extensor retinaculum
8. Tendon of extensor carpi radialis brevis m.
9. Tendon of extensor pollicis longus m.
10. Tendon of extensor carpi radialis longus m.
11. Superficial venous arch
12. Articular capsule of metacarpophalangeal joint
13. Fibrous digital sheath



**Table 8.9** Muscles that act on the wrist, hand, and fingers.

| <b>Antebrachial Muscle</b>            | <b>Origin(s)</b>  | <b>Insertion(s)</b>                       | <b>Action</b>                                   | <b>Innervation</b>  |
|---------------------------------------|---|---|---|---------------------|
| <b>Supinator</b>                      | Lateral epicondyle of humerus and crest of ulna           | Lateral surface of radius                 | Supinates forearm and hand                      | Radial n.           |
| <b>Pronator teres</b>                 | Medial epicondyle of humerus                              | Lateral surface of radius                 | Pronates forearm and hand                       | Median n.           |
| <b>Pronator quadratus</b>             | Distal fourth of ulna                                     | Distal fourth of radius                   | Pronates forearm and hand                       | Median n.           |
| <b>Flexor carpi radialis</b>          | Medial epicondyle of humerus                              | Base of second and third metacarpal bones | Flexes and abducts wrist                        | Median n.           |
| <b>Palmaris longus</b>                | Medial epicondyle of humerus                              | Palmar aponeurosis                        | Flexes wrist                                    | Median n.           |
| <b>Flexor carpi ulnaris</b>           | Medial epicondyle of humerus and olecranon of ulna        | Carpal and metacarpal bones               | Flexes and adducts wrist                        | Ulnar n.            |
| <b>Flexor digitorum superficialis</b> | Medial epicondyle of humerus and coronoid process of ulna | Middle phalanges of digits II–V           | Flexes wrist and digits                         | Median n.           |
| <b>Flexor digitorum profundus</b>     | Proximal two-thirds of ulna and interosseous ligament     | Distal phalanges of digits II–V           | Flexes wrist and digits                         | Median and ulnar n. |
| <b>Flexor pollicis longus</b>         | Body of radius and coronoid process of ulna               | Distal phalanx of thumb                   | Flexes joints of thumb                          | Median n.           |
| <b>Extensor carpi radialis longus</b> | Lateral supracondylar ridge of humerus                    | Second metacarpal bone                    | Extends and abducts wrist                       | Radial n.           |
| <b>Extensor carpi radialis brevis</b> | Lateral epicondyle of humerus                             | Third metacarpal bone                     | Extends and abducts wrist                       | Radial n.           |
| <b>Extensor digitorum</b>             | Lateral epicondyle of humerus                             | Posterior surfaces of digits II–V         | Extends wrist and phalanges                     | Radial n.           |
| <b>Extensor digiti minimi</b>         | Lateral epicondyle of humerus                             | Extensor aponeurosis of fifth digit       | Extends joints of fifth digit and wrist         | Radial n.           |
| <b>Extensor carpi ulnaris</b>         | Lateral epicondyle of humerus and olecranon of ulna       | Base of fifth metacarpal bone             | Extends and adducts wrist                       | Radial n.           |
| <b>Extensor pollicis longus</b>       | Lateral and posterior surface of ulna                     | Base of distal phalanx of thumb           | Extends joints of thumb; abducts joints of hand | Radial n.           |
| <b>Extensor pollicis brevis</b>       | Distal body of radius and interosseous ligament           | Base of proximal phalanx of thumb         | Extends joints of thumb; abducts joints of hand | Radial n.           |
| <b>Abductor pollicis longus</b>       | Distal radius and ulna and interosseous ligament          | Base of first metacarpal bone             | Abducts joints of thumb and joints of hand      | Radial n.           |



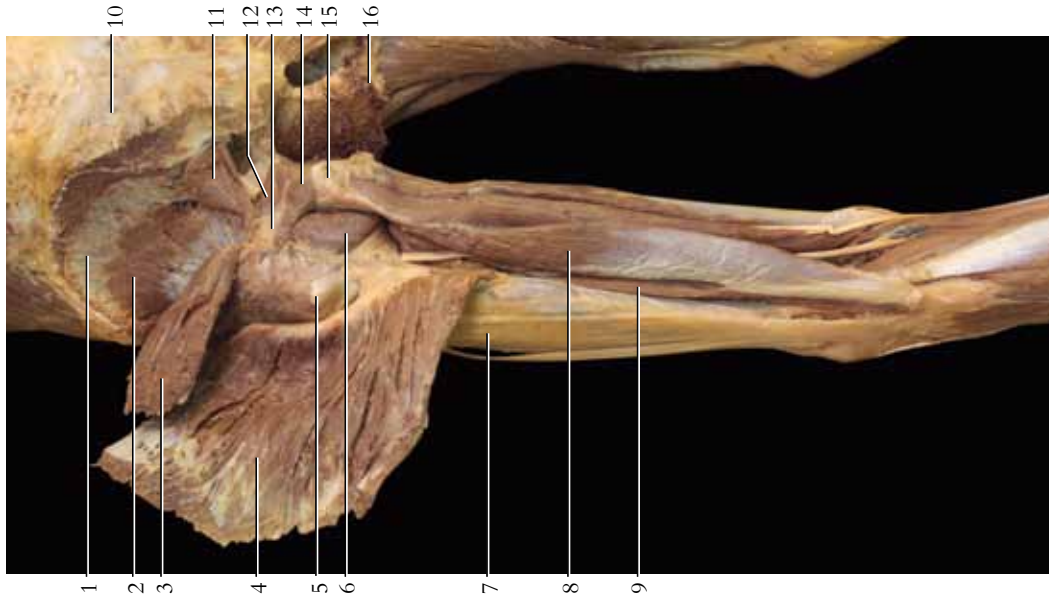
**Figure 8.38** The superficial muscles of gluteal and thigh regions.

1. Gluteus maximus m.
2. Greater trochanter
3. Iliotibial band of fascia
4. Biceps femoris m. (long head)
5. Biceps femoris m. (short head)
6. Semitendinosus m.
7. Semimembranosus m.
8. Sacrum
9. Anus



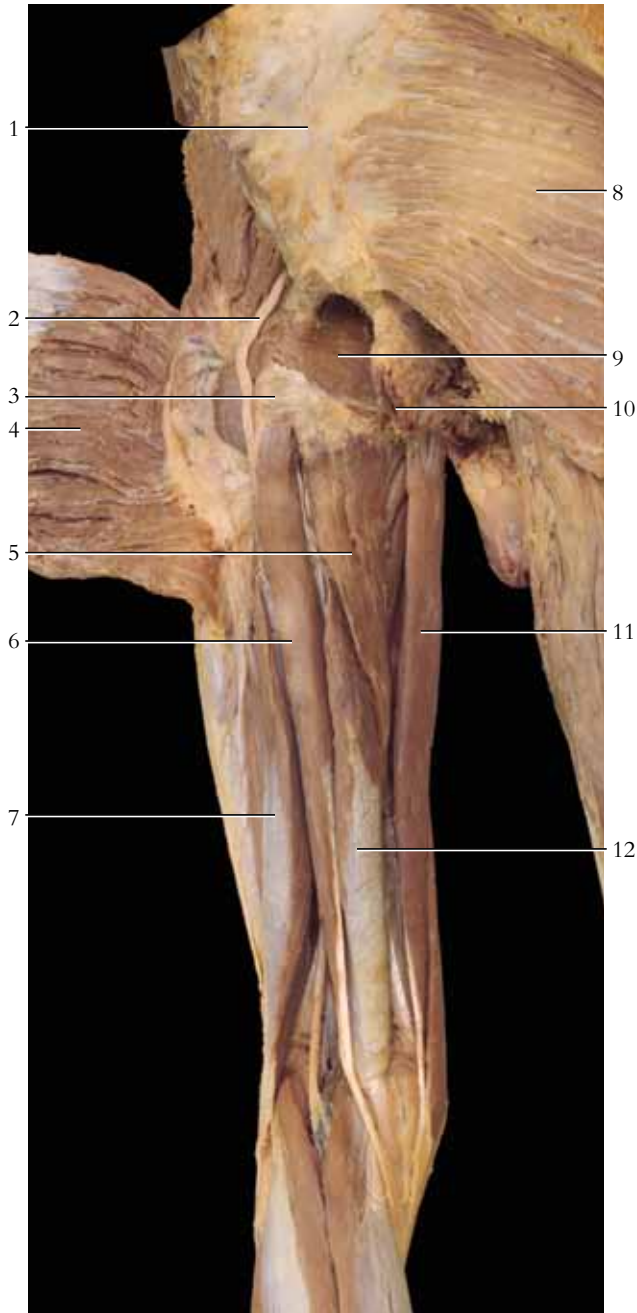
**Figure 8.39** The mid structures of gluteal region.

1. Gluteus medius m.
2. Piriformis m.
3. Gluteus maximus m. (cut and reflected)
4. Sciatic nerve
5. Greater trochanter
6. Quadratus femoris m.
7. Iliotibial band of fascia
8. Biceps femoris m. (long head)
9. Biceps femoris m. (short head)
10. Sacrum
11. Sacrospinous ligament
12. Superior gemellus m.
13. Obturator internus m.
14. Inferior gemellus m.
15. Ischial tuberosity
16. Anus



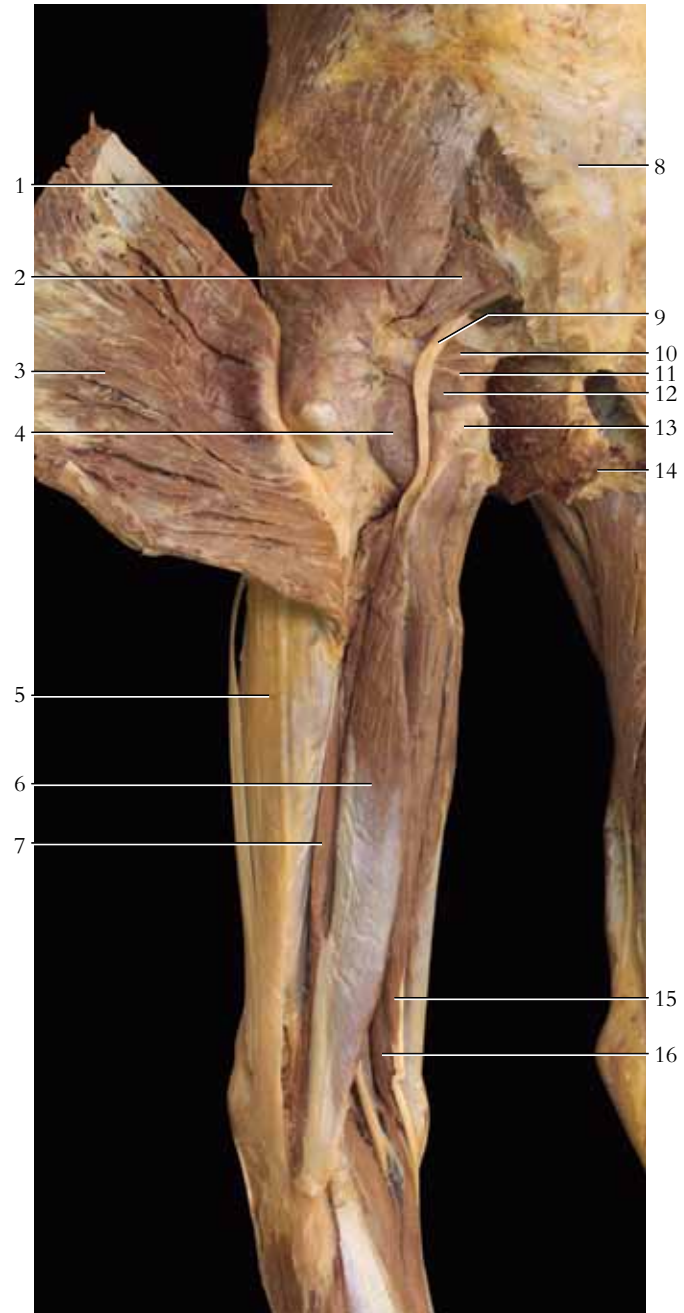
**Figure 8.40** The deep structures of gluteal region.

1. Ilium
2. Biceps femoris m. (short head)
3. Gluteus minimus m.
4. Gluteus medius m. (cut and reflected)
5. Gluteus maximus m. (cut and reflected)
6. Greater trochanter
7. Quadratus femoris m.
8. Iliotibial band of fascia
9. Biceps femoris m. (long head)
10. Sacrum
11. Piriformis m.
12. Superior gemellus m.
13. Obturator internus m.
14. Inferior gemellus m.
15. Ischial tuberosity
16. Anus



**Figure 8.41** A posteromedial view of the posterior structures of thigh region.

1. Sacrum
2. Sciatic nerve
3. Ischial tuberosity
4. Gluteus maximus m. (left side) (cut and reflected)
5. Adductor magnus m.
6. Semitendinosus m.
7. Biceps femoris m.
8. Gluteus maximus m. (right side)
9. Obturator internus m.
10. Anus
11. Gracilis m.
12. Semimembranosus m.



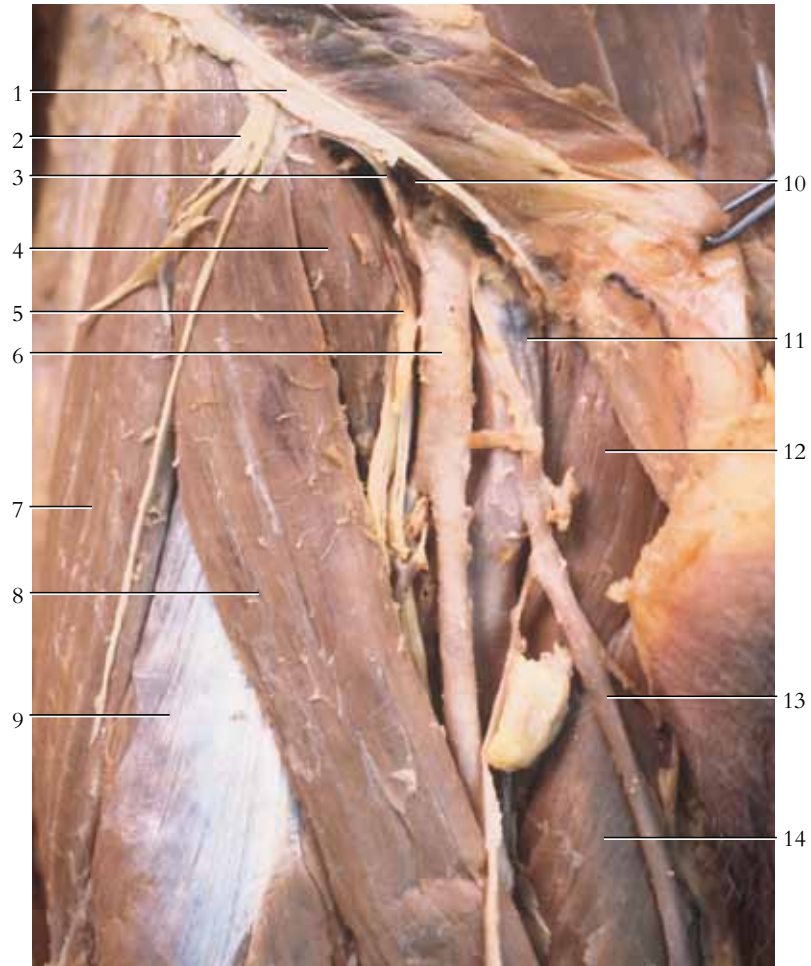
**Figure 8.42** A posterolateral view of the posterior structures of thigh region.

- |   |                           |
|---|---------------------------|
| 1. Gluteus medius m.                                  | 8. Sacrum                 |
| 2. Piriformis m.                                      | 9. Sciatic nerve          |
| 3. Gluteus maximus m. (left side) (cut and reflected) | 10. Superior gemellus m.  |
| 4. Quadratus femoris m.                               | 11. Obturator internus m. |
| 5. Iliotibial band                                    | 12. Inferior gemellus m.  |
| 6. Biceps femoris m. (long head)                      | 13. Ischial tuberosity    |
| 7. Biceps femoris m. (short head)                     | 14. Anus                  |
|   | 15. Semitendinosus m.     |
|   | 16. Semimembranosus       |



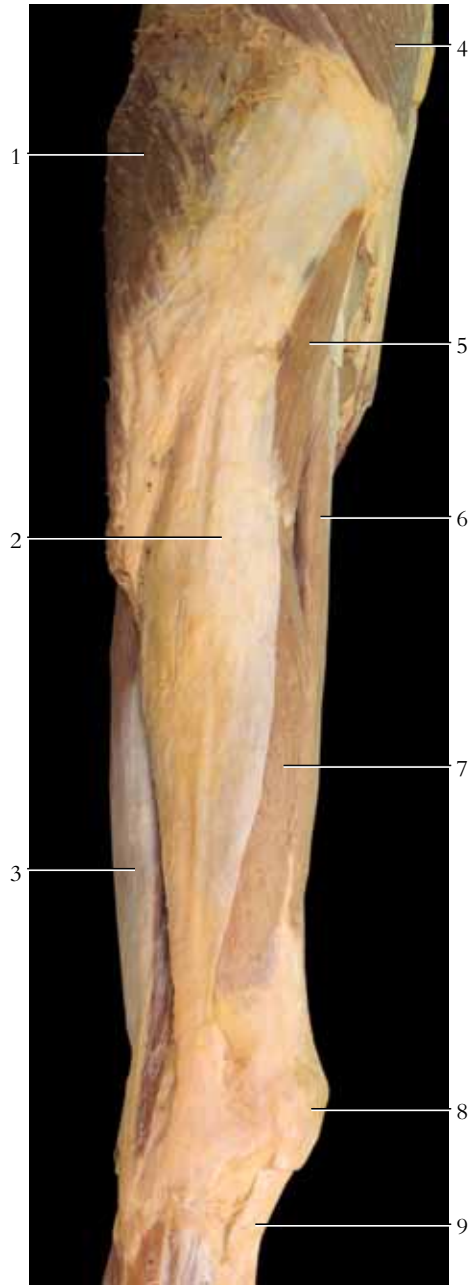
**Figure 8.43** An anterior view of the right femoral triangle.

1. Inguinal ligament
2. Lateral femoral cutaneous nerve
3. Superficial circumflex iliac artery
4. Iliopsoas m.
5. Femoral nerve
6. Femoral artery
7. Tensor fasciae latae m.
8. Sartorius m.
9. Rectus femoris m.
10. Femoral ring
11. Femoral vein
12. Pectineus m.
13. Great saphenous vein
14. Adductor longus m.



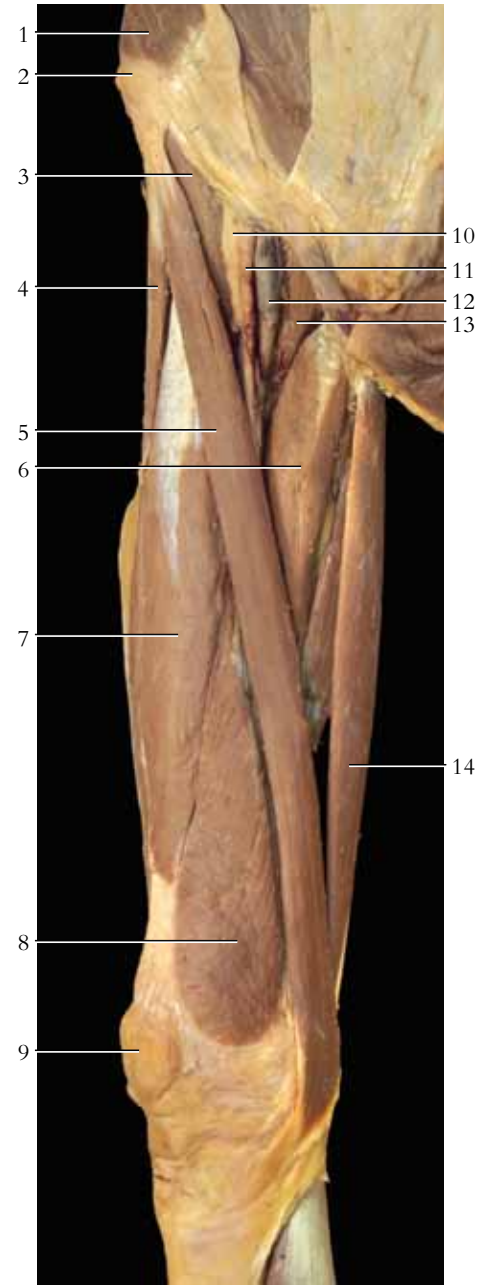
**Table 8.10** Muscles that act on the thigh at the hip joint.

| Pelvic Muscle               | Origin(s)   | Insertion(s)                                       | Action   | Innervation         |
|-----------------------------|---|--|--|---------------------|
| <b>Iliacus</b>              | Iliac fossa   | Lesser trochanter of femur, along with psoas major | Flexes at the hip joint; flexes joints of vertebral column | Femoral n.          |
| <b>Psoas major</b>          | Transverse process of lumbar vertebrae                    | Lesser trochanter of femur, along with iliacus     | Flexes at the hip joint; flexes joints of vertebral column | Spinal nn. L2, L3   |
| <b>Gluteus maximus</b>      | Iliac crest, sacrum, coccyx, aponeurosis of lumbar region | Gluteal tuberosity and iliotibial tract            | Extends and rotates thigh laterally at the hip joint       | Inferior gluteal n. |
| <b>Gluteus medius</b>       | Lateral surface of ilium                                  | Greater trochanter of femur                        | Abducts and rotates thigh medially at the hip joint        | Superior gluteal n. |
| <b>Gluteus minimus</b>      | Lateral surface of lower half of ilium                    | Greater trochanter of femur                        | Abducts and rotates thigh medially at the hip joint        | Superior gluteal n. |
| <b>Tensor fasciae latae</b> | Anterior border of ilium and iliac crest                  | Iliotibial tract                                   | Abducts and rotates thigh medially at the hip joint        | Superior gluteal n. |



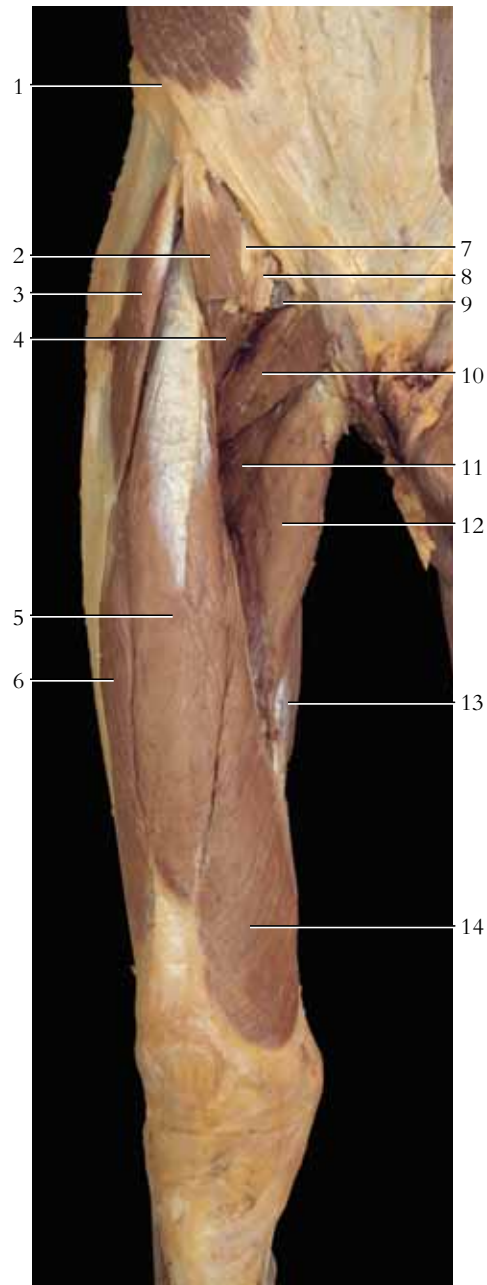
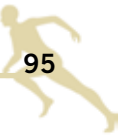
**Figure 8.44** A lateral view of the right thigh.

1. Gluteus maximus m.
2. Iliotibial band
3. Biceps femoris m.
4. External oblique m.
5. Tensor fascia lata m.
6. Rectus femoris m.
7. Vastus lateralis m.
8. Patella
9. Patellar ligament



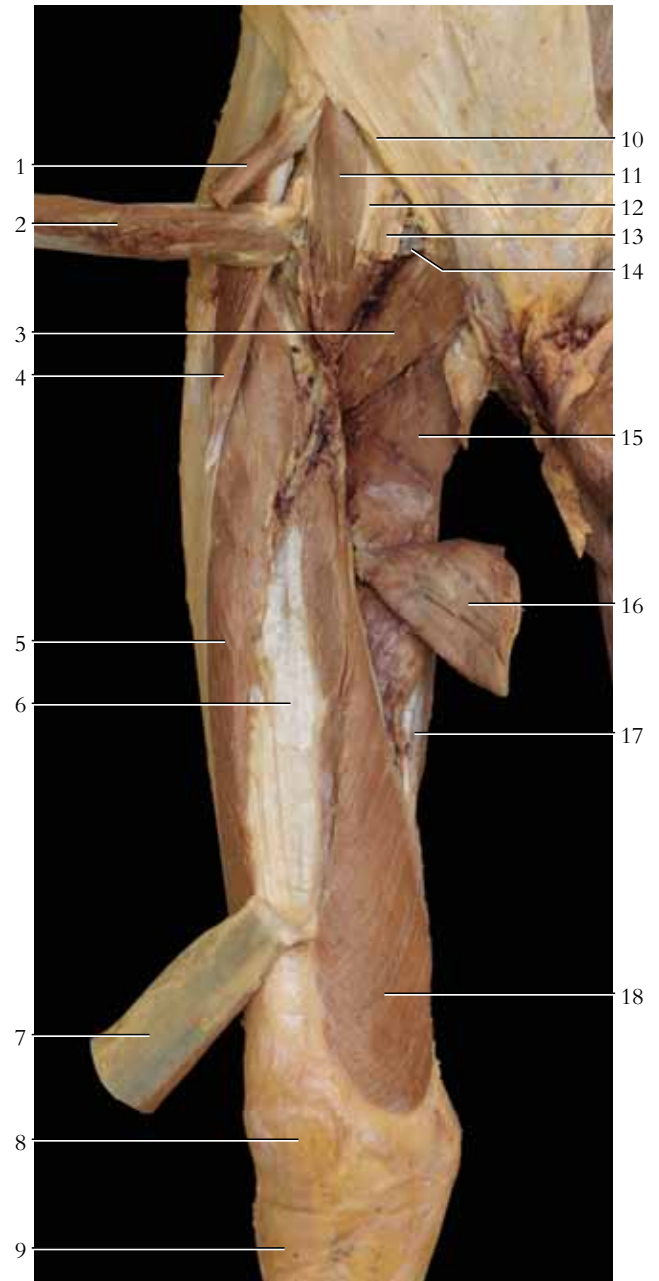
**Figure 8.45** An anteromedial view of the right thigh.

1. External oblique m.
2. Anterior superior iliac spine
3. Iliopsoas m.
4. Tensor fascia lata m.
5. Sartorius m.
6. Adductor longus m.
7. Rectus femoris m.
8. Vastus medialis m.
9. Patella
10. Femoral nerve
11. Femoral artery
12. Femoral vein
13. Pectineus m.
14. Gracilis m.



**Figure 8.46** An anterior view of the right thigh.

1. Anterior superior iliac spine
2. Sartorius m. (cut)
3. Tensor fascia lata m.
4. Iliopsoas m.
5. Rectus femoris m.
6. Vastus lateralis m.
7. Femoral nerve (cut)
8. Femoral artery (cut)
9. Femoral vein (cut)
10. Pectineus m.
11. Adductor brevis m.
12. Adductor longus m.
13. Adductor magnus m.
14. Vastus medialis m.



**Figure 8.47** An anterior view of the deep structures of the right thigh.

- |  |                          |
|--|--------------------------|
| 1. Sartorius m. (cut and reflected)      | 9. Patellar ligament     |
| 2. Rectus femoris m. (cut and reflected) | 10. Inguinal ligament    |
| 3. Pectineus m.                          | 11. Iliopsoas m.         |
| 4. Tensor fascia lata m.                 | 12. Femoral nerve (cut)  |
| 5. Vastus lateralis m.                   | 13. Femoral artery (cut) |
| 6. Vastus intermedius m.                 | 14. Femoral vein (cut)   |
| 7. Rectus femoris m. (cut and reflected) | 15. Adductor brevis m.   |
| 8. Patella                               | 16. Adductor longus m.   |
|  | 17. Adductor magnus m.   |
|  | 18. Vastus medialis m.   |



**Table 8.11** Medial muscles that move the thigh at the hip joint.

| Adductor Muscle        | Origin(s)   | Insertion(s)                                | Action   | Innervation              |
|------------------------|---|---|--|--------------------------|
| <b>Gracilis</b>        | Inferior edge of symphysis pubis                      | Proximomedial surface of tibia              | Adducts thigh at hip joint; flexes leg at knee joint | Obturator n.             |
| <b>Pectineus</b>       | Pectineal line of pubis                               | Distal to lesser trochanter of femur        | Adducts and flexes thigh at hip joint                | Femoral n.               |
| <b>Adductor longus</b> | Pubis—below pubic crest                               | Linea aspera of femur                       | Adducts thigh at hip joint                           | Obturator n.             |
| <b>Adductor brevis</b> | Inferior ramus of pubis                               | Linea aspera of femur                       | Adducts thigh at hip joint                           | Obturator n.             |
| <b>Adductor magnus</b> | Inferior ramus of ischium and inferior ramus of pubis | Linea aspera and medial epicondyle of femur | Adducts thigh at hip joint                           | Obturator and tibial nn. |

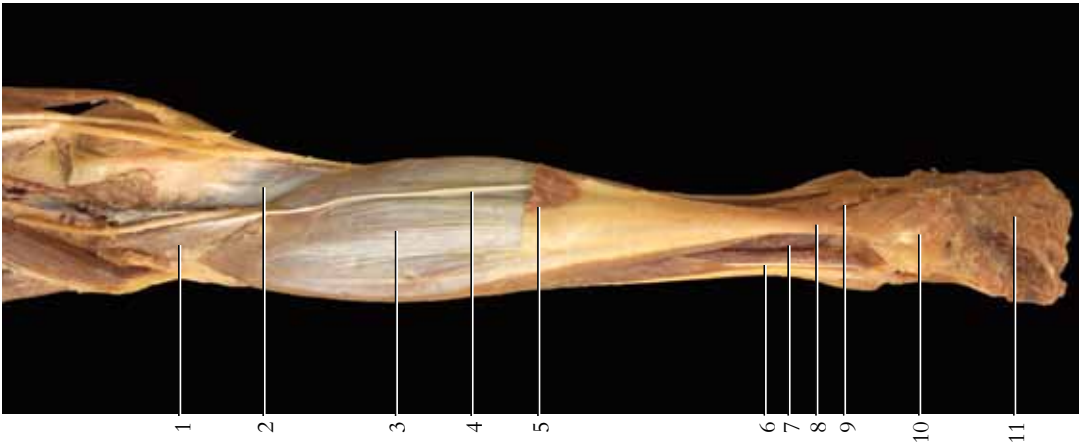
**Table 8.12** Muscles of the thigh that act on the leg.

| Thigh Muscle              | Origin(s)  | Insertion(s)  | Action  | Innervation |
|---------------------------|--|---|---|-------------|
| <b>Sartorius</b>          | Anterior superior iliac spine                                  | Medial surface of tibia   | Flexes leg and thigh; abducts rotates thigh laterally | Femoral n.  |
| <b>Quadriceps femoris</b> |  | Patella by common tendon, which continues as patellar ligament to tibial tuberosity | Extends leg at knee joint                             | Femoral n.  |
| <b>Rectus femoris</b>     | Anterior inferior iliac spine                                  |   |   |             |
| <b>Vastus lateralis</b>   | Inferior to greater trochanter and linea aspera of femur       |   |   |             |
| <b>Vastus medialis</b>    | Medial surface and linea aspera of femur                       |   |   |             |
| <b>Vastus intermedius</b> | Anterior and lateral surfaces of femur                         |   |   |             |
| <b>Biceps femoris</b>     | Long head—ischial tuberosity; short head—linea aspera of femur | Head of fibula and proximolateral part of tibia                                     | Extends thigh at hip joint; flexes leg at knee joint  | Tibial n.   |
| <b>Semitendinosus</b>     | Ischial tuberosity   | Proximomedial surface of tibia  | Extends thigh at hip joint; flexes leg at knee joint  | Tibial n.   |
| <b>Semimembranosus</b>    | Ischial tuberosity   | Proximomedial surface of tibia  | Extends thigh at hip joint; flexes leg at knee joint  | Tibial n.   |



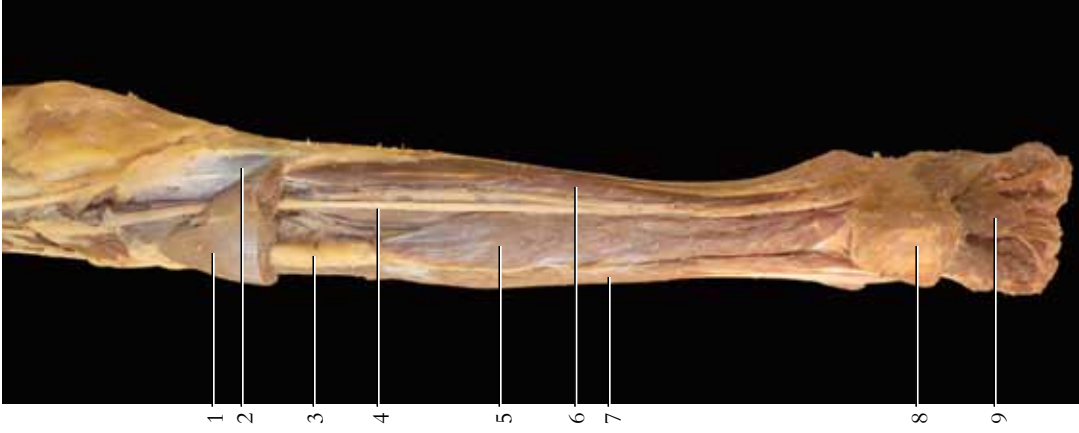
**Figure 8.48** A posterior superficial view of lower leg.

1. Lateral head of gastrocnemius m.
2. Medial head of gastrocnemius m.
3. Soleus m.
4. Fibularis longus and brevis mm.
5. Flexor hallucis longus m.
6. Calcaneal tendon (achilles tendon)
7. Tendon of flexor hallucis longus m.
8. Calcaneus
9. Plantar aponeurosis



**Figure 8.49** A posterior view of lower leg.

1. Plantaris m.
2. Popliteus m.
3. Soleus m.
4. Plantaris tendon
5. Gastrocnemius m. (cut)
6. Fibularis longus and brevis mm.
7. Flexor hallucis longus m.
8. Calcaneal tendon (achilles tendon)
9. Tendon of flexor hallucis longus m.
10. Calcaneus
11. Plantar aponeurosis



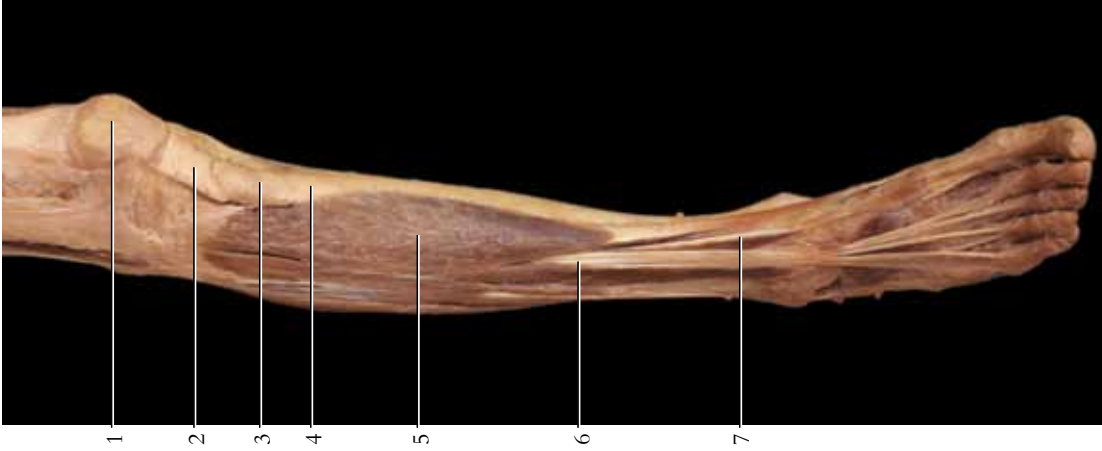
**Figure 8.50** A posterior deep view of lower leg.

1. Soleus m. (cut)
2. Popliteus m.
3. Fibula
4. Tibial nerve
5. Flexor hallucis longus m.
6. Flexor digitorum longus m.
7. Fibularis longus m.
8. Calcaneus
9. Flexor digitorum brevis m.



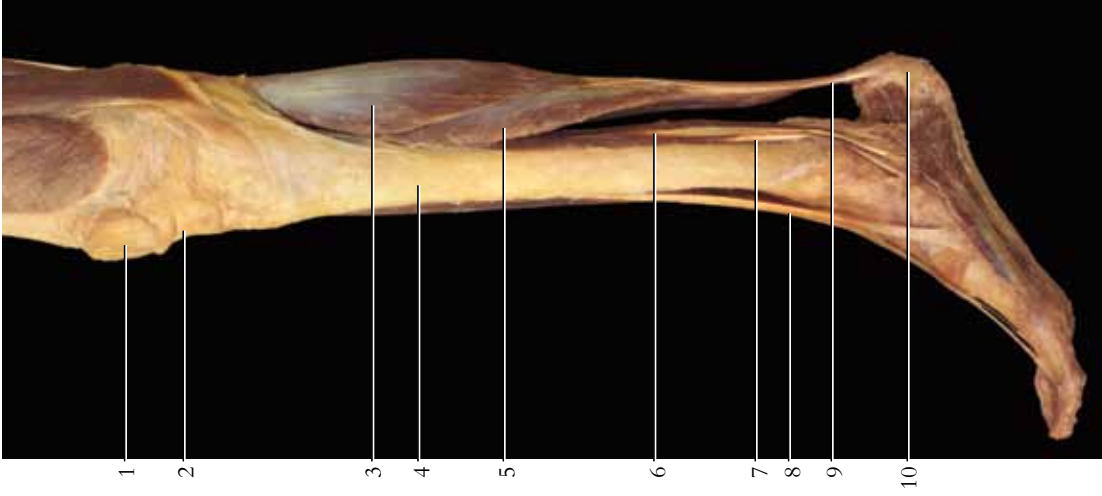
**Figure 8.51** A lateral view of lower leg.

1. Patella
2. Soleus m. (cut)
3. Extensor digitorum longus m.
4. Tendon of fibularis longus m.
5. Fibularis brevis m.
6. Calcaneus
7. Extensor digitorum brevis m.
8. Tendon of fibularis longus m.
9. Tendon of fibularis brevis m.
10. Tendon of fibularis tertius m.



**Figure 8.52** An anterior view of lower leg.

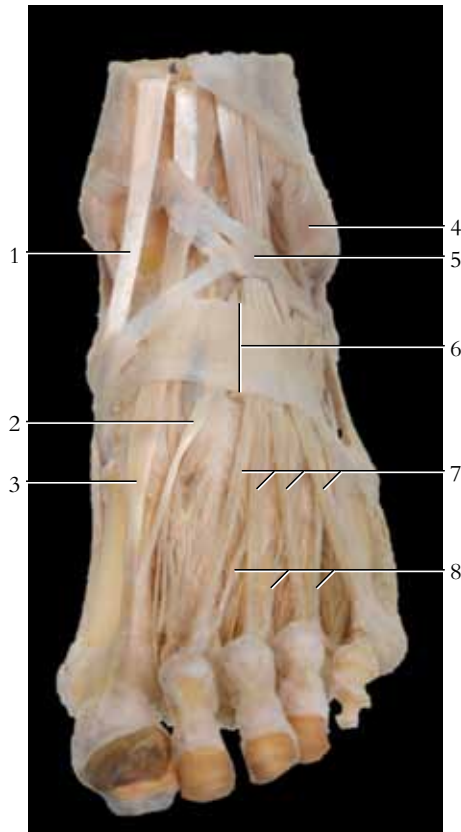
1. Patella
2. Patellar ligament
3. Tibial tuberosity
4. Tibia
5. Tibialis anterior m.
6. Tendon of extensor digitorum longus m.
7. Tendon of extensor hallucis longus m.



**Figure 8.53** A medial view of lower leg.

1. Patella
2. Patellar ligament
3. Gastrocnemius m.
4. Tibia
5. Soleus m.
6. Flexor digitorum longus m.
7. Tendon of tibialis posterior m.
8. Tendon of tibialis anterior m.
9. Calcaneal tendon (achilles tendon)
10. Calcaneus





**Figure 8.54** An anterior view of dorsum of foot.

1. Tendon of tibialis anterior m.
2. Tendon of extensor hallucis brevis m.
3. Tendon of extensor hallucis longus m.
4. Lateral malleolus
5. Superior extensor retinaculum
6. Inferior extensor retinaculum
7. Tendon of extensor digitorum longus m.
8. Tendon of extensor digitorum brevis m.



**Figure 8.55** A medial view of the right foot.

1. Tendon of tibialis anterior m.
2. Extensor retinaculum
3. Medial cuneiform
4. Tendon of extensor hallucis longus m.
5. First metatarsal bone
6. Proximal phalanx of hallux
7. Medial malleolus of tibia
8. Tendon of tibialis posterior m.
9. Tendo calcaneus
10. Tendon of flexor digitorum longus m.
11. Abductor hallucis m.



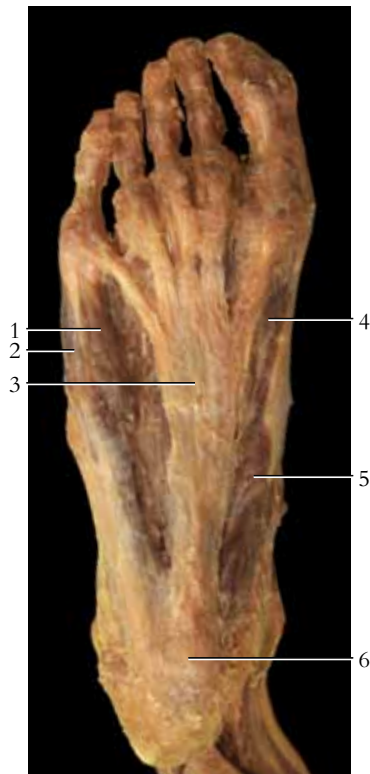
**Figure 8.56** A lateral view of the right foot.

1. Tendon of tibialis anterior
2. Tendon of extensor digitorum longus m.
3. Tendon of fibularis tertius m.
4. Superior extensor retinaculum
5. Inferior extensor retinaculum
6. Lateral malleolus of fibula
7. Extensor digitorum brevis m.
8. Tendon of fibularis longus m.
9. Tendon of fibularis brevis m.
10. Calcaneus
11. Fifth metatarsal bone



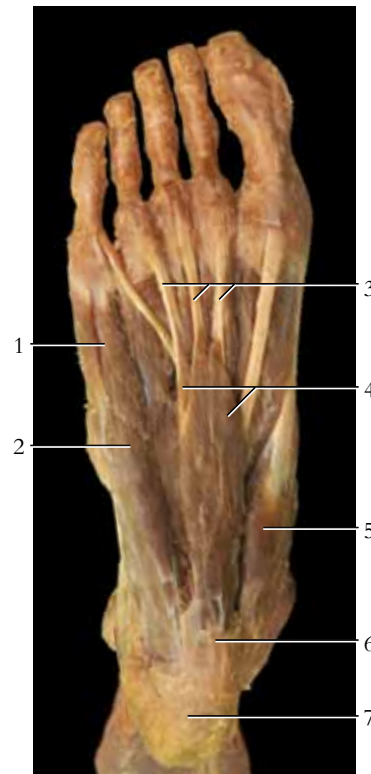
**Figure 8.57** A superficial view of plantar region.

1. Flexor digiti minimi m.
2. Abductor digiti minimi m.
3. Plantar aponeurosis
4. Flexor hallucis brevis m.
5. Adductor hallucis m.
6. Calcaneus



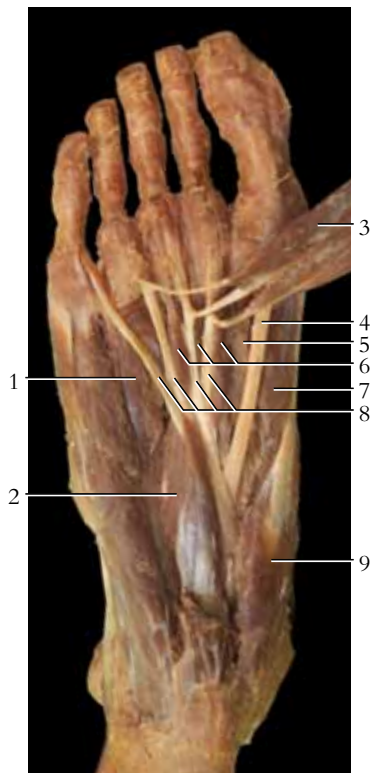
**Figure 8.58** A view of plantar region.

1. Flexor digiti minimi brevis m.
2. Abductor digiti minimi m.
3. Tendons of flexor digitorum brevis m.
4. Flexor digitorum brevis m.
5. Abductor hallucis m.
6. Plantar aponeurosis (cut)
7. Calcaneal tuberosity



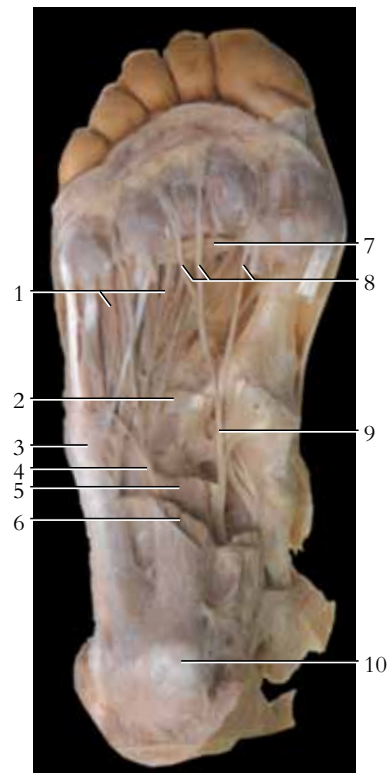
**Figure 8.59** A deep view of plantar region.

1. Interosseous m.
2. Quadratus plantae m.
3. Flexor digitorum brevis m. (cut and reflected)
4. Tendon of flexor hallucis longus m.
5. Oblique head of adductor hallucis m.
6. Lumbrical mm.
7. Flexor hallucis brevis m.
8. Tendons of flexor digitorum longus m.
9. Abductor hallucis m.



**Figure 8.60** A deep view of plantar region.

1. Interosseous mm.
2. Oblique head of adductor hallucis m. (cut)
3. Abductor digiti minimi m.
4. Lateral plantar nerve
5. Quadratus plantae m. (cut)
6. Flexor digitorum brevis m. (cut)
7. Transverse head, adductor hallucis m.
8. Common plantar digital nerve
9. Medial plantar nerve
10. Calcaneal tuberosity



**Table 8.13** Muscles of the leg that move the ankle, foot, and toes.

| Leg Muscle                       | Origin(s)   | Insertion(s)  | Action  | Innervation            |
|----------------------------------|---|---|---|------------------------|
| <b>Tibialis anterior</b>         | Lateral condyle and body of tibia                       | First metatarsal bone and first cuneiform bone      | Dorsiflexes ankle; inverts foot and ankle                         | Deep fibular n.        |
| <b>Extensor digitorum longus</b> | Lateral condyle of tibia and anterior surface of fibula | Extensor expansions of digits II–V                  | Extends digits II–V; dorsiflexes foot at ankle                    | Deep fibular n.        |
| <b>Extensor hallucis longus</b>  | Anterior surface of fibula and interosseous ligament    | Distal phalanx of digit I                           | Extends joints of big toe; assists dorsiflexion of foot at ankle  | Deep fibular n.        |
| <b>Fibularis tertius</b>         | Anterior surface of fibula and interosseous ligament    | Dorsal surface of fifth metatarsal bone             | Dorsiflexes and everts foot at ankle                              | Deep fibular n.        |
| <b>Fibularis longus</b>          | Lateral condyle of tibia and head and shaft of fibula   | First cuneiform and metatarsal bone I               | Plantar flexes and everts foot at ankle                           | Superficial fibular n. |
| <b>Fibularis brevis</b>          | Lower aspect of fibula                                  | Metatarsal bone V                                   | Plantar flexes and everts foot at ankle                           | Superficial fibular n. |
| <b>Gastrocnemius</b>             | Lateral and medial condyle of femur                     | Posterior surface of calcaneus via calcaneal tendon | Plantar flexes foot at ankle; flexes knee joint                   | Tibial n.              |
| <b>Soleus</b>                    | Posterior aspect of fibula and tibia                    | Calcaneus via calcaneal tendon                      | Plantar flexes foot at ankle                                      | Tibial n.              |
| <b>Plantaris</b>                 | Supracondylar ridge of femur                            | Calcaneus   | Plantar flexes foot at ankle                                      | Tibial n.              |
| <b>Popliteus</b>                 | Lateral condyle of femur                                | Upper posterior aspect of tibia                     | Flexes and medially rotates leg at knee joint                     | Tibial n.              |
| <b>Flexor hallucis longus</b>    | Posterior surface of tibia                              | Distal phalanx of big toe                           | Flexes joint of great toe and plantar flexes foot                 | Tibial n.              |
| <b>Flexor digitorum longus</b>   | Posterior surface of tibia                              | Distal phalanges of digits II–V                     | Flexes joints of digits II–V and plantar flexes foot              | Tibial n.              |
| <b>Tibialis posterior</b>        | Tibia and fibula and interosseous ligament bones II–IV  | Navicular, cuneiform, cuboid, and metatarsal bones  | Plantar flexes and inverts foot at ankle; supports arches of foot | Tibial n.              |

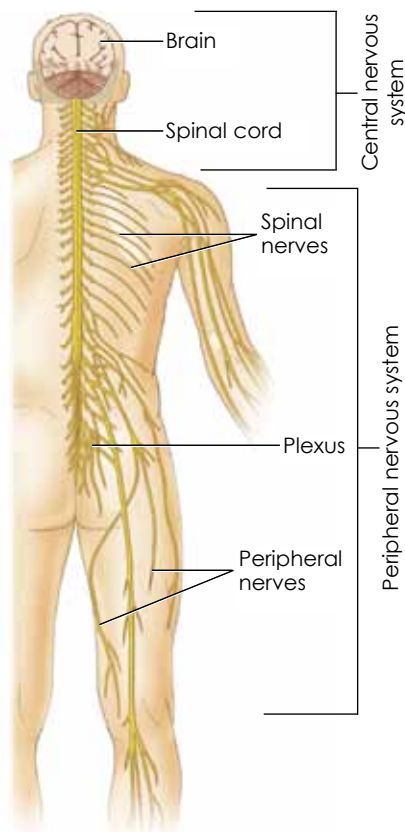


# Chapter 9

## Nervous System

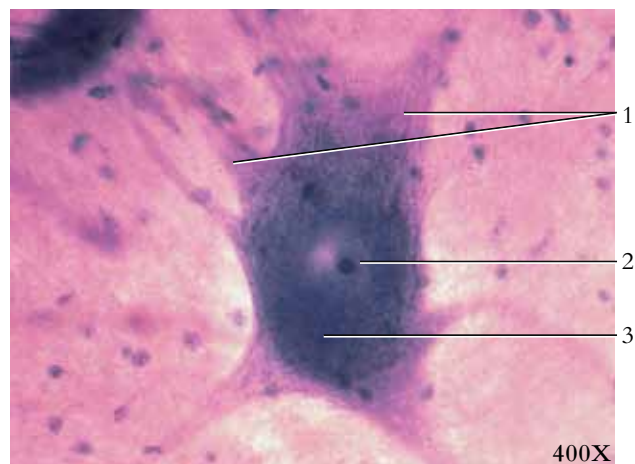
The nervous system is anatomically divided into the **central nervous system (CNS)**, which includes the **brain** and **spinal cord**, and the **peripheral nervous system (PNS)**, which includes the **cranial nerves**, arising from the brain, and the **spinal nerves** and ganglia, arising from the spinal cord (fig. 9.1). The **autonomic nervous system (ANS)** is a functionally distinct division of the nervous system devoted to regulation of involuntary activities in the body. The ANS is made up of specific portions of the CNS and PNS.

The brain and spinal cord are the centers for integration and coordination of information. Conveyed as **nerve impulses**, information to and from the brain and spinal cord travels through **nerves**. Nerves are similar to electrical conducting wires. Nerve impulses are sent from the brain in the form of electrical signals along **motor nerves** to the receiving organs, which then translate the signal into some specific function. For example, the motor impulses conducted from the brain to the muscles of the forearm that serve the hand cause the fingers to move as the muscles are contracted. **Sensory nerves** conduct action potentials (nerve impulses) in the opposite direction—from the receptor site to the CNS. For example, a pinprick on the skin produces a sensory impulse along a sensory nerve that the brain interprets as a painful sensation.

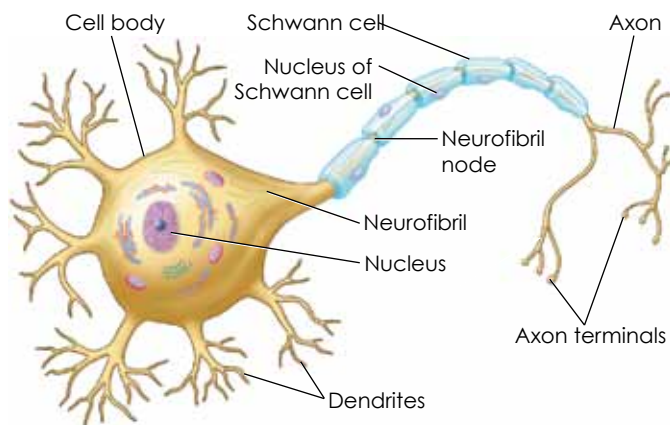


**Figure 9.1** The divisions of the nervous system.

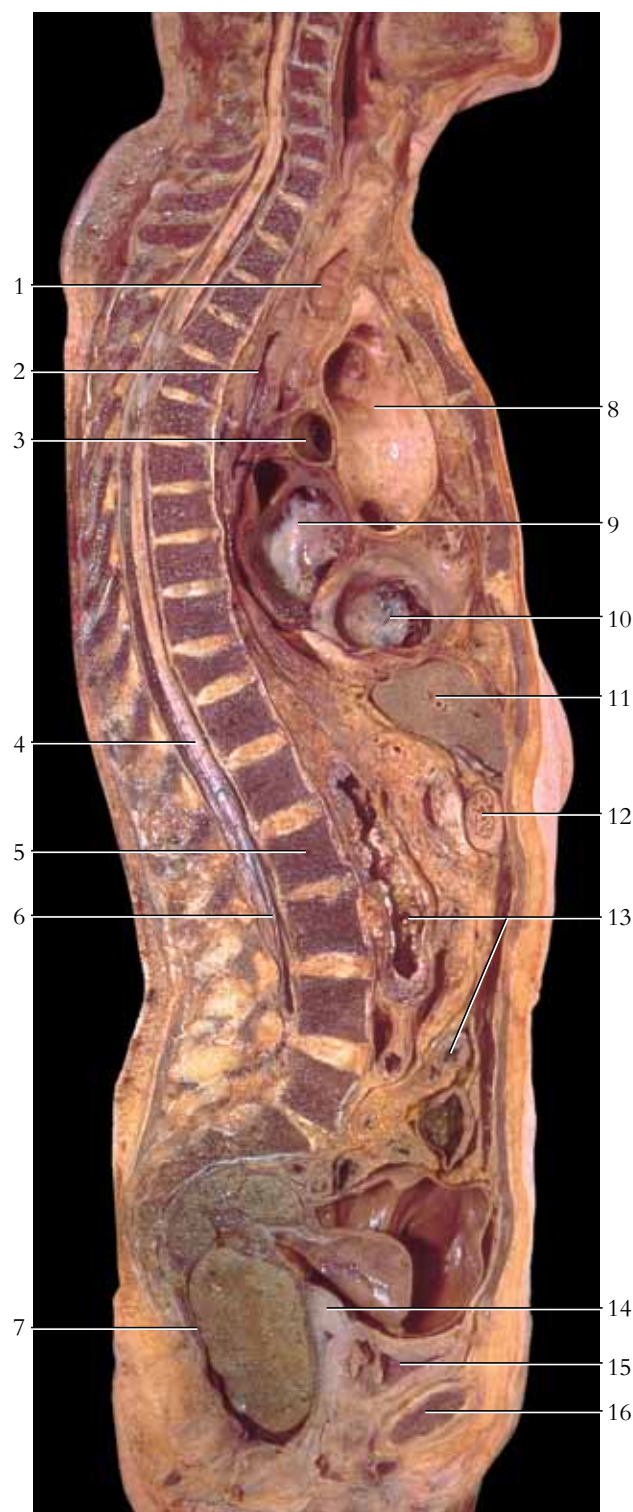
**Neurons** and **neuroglia** are the two cell types that make up nervous tissue. Neurons are specialized to respond to physical and chemical stimuli, conduct impulses, and release specific chemical regulators, called **neurotransmitters**. Although neurons vary considerably in size and shape, they have three principal components: a **cell body**, **dendrites**, and an **axon** (fig. 9.3). In a typical neuron connection, the axon of one neuron **synapses** (joins) on the cell body or dendrites of a neighboring neuron. Axons vary in length from a few millimeters in the CNS to over a meter in the PNS. Long axons are generally **myelinated** with **Schwann cells (neurolemmocytes)** in the PNS, and many of the short axons are myelinated with **oligodendrocytes** in the CNS. **Neurofibril nodes (nodes of Ranvier)** are segments in the **myelin sheath**. The end of the axon at the synapse is called the **axon terminal**.



**Figure 9.2** A photomicrograph of a neuron.  
1. Cytoplasmic extensions      3. Cell body of neuron  
2. Nucleus

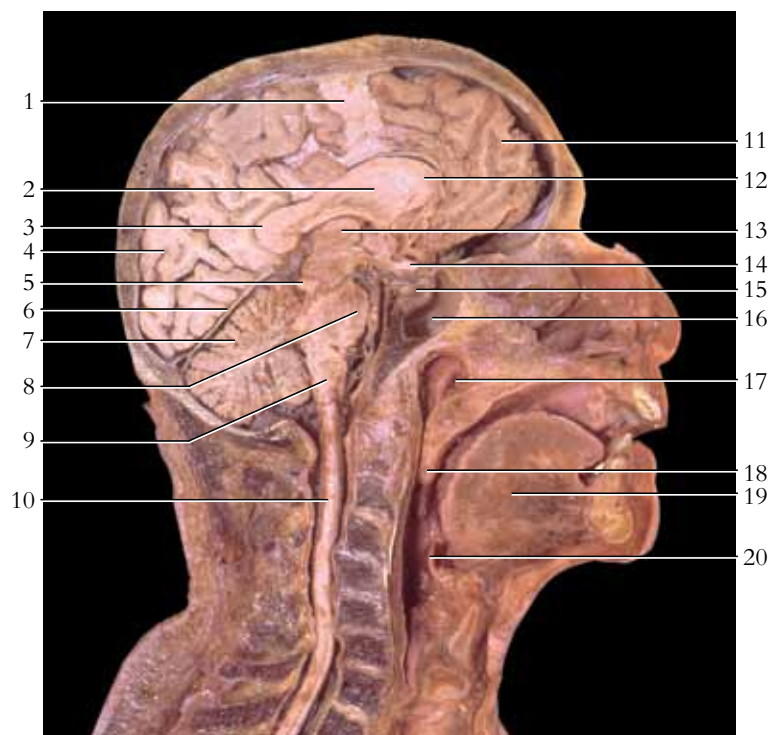


**Figure 9.3** The structure of a myelinated neuron.



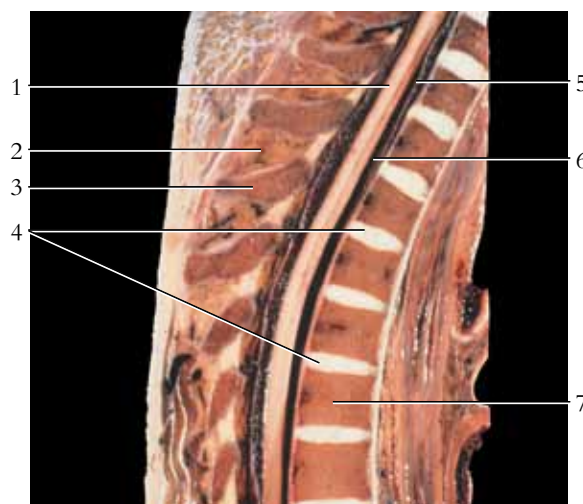
**Figure 9.4** A sagittal section of the female trunk.

- |                            |                     |
|----------------------------|---------------------|
| 1. Trachea                 | 9. Right atrium     |
| 2. Esophagus               | 10. Right ventricle |
| 3. Pulmonary artery        | 11. Liver           |
| 4. Spinal cord             | 12. Stomach         |
| 5. Body of lumbar vertebra | 13. Small Intestine |
| 6. Cauda equina            | 14. Uterus          |
| 7. Rectum                  | 15. Urinary bladder |
| 8. Aorta                   | 16. Pubic bone      |



**Figure 9.5** A sagittal section of the head and neck.

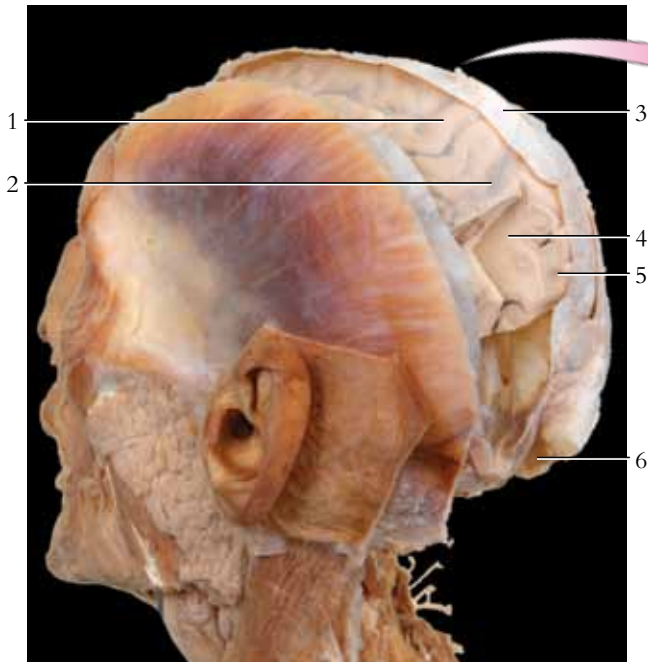
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|-------------------------------|---|
| 1. Remnant of falx cerebri    | 12. Splenium of corpus callosum         |
| 2. Septum pellucidum          | 13. Thalamus                            |
| 3. Genu of corpus callosum    | 14. Optic chiasma                       |
| 4. Occipital lobe of cerebrum | 15. Pituitary gland                     |
| 5. Corpora quadrigemina       | 16. Sphenoidal sinus                    |
| 6. Falx cerebelli             | 17. Pharyngeal opening of auditory tube |
| 7. Cerebellum                 | 18. Uvula                               |
| 8. Pons                       | 19. Tongue                              |
| 9. Medulla oblongata          | 20. Epiglottis                          |
| 10. Spinal cord               |   |
| 11. Frontal lobe of cerebrum  |   |



**Figure 9.6** A sagittal section of the spinal column in the cervical and superior thoracic regions.

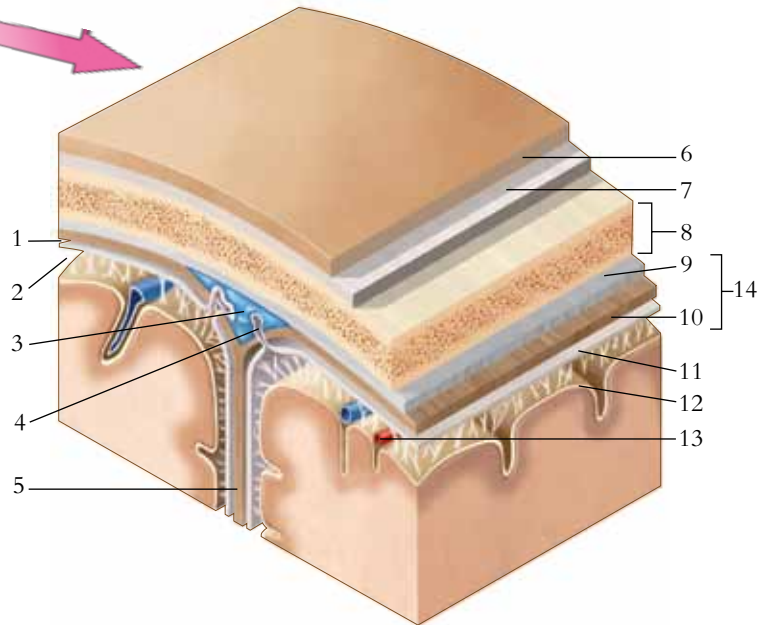
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|---------------------------------|-------------------------|
| 1. Spinal cord                  | 4. Intervertebral discs |
| 2. Semispinalis cervicis muscle | 5. Dura mater           |
| 3. Spinous process              | 6. Subarachnoid space   |
|                                 | 7. Body of vertebra     |





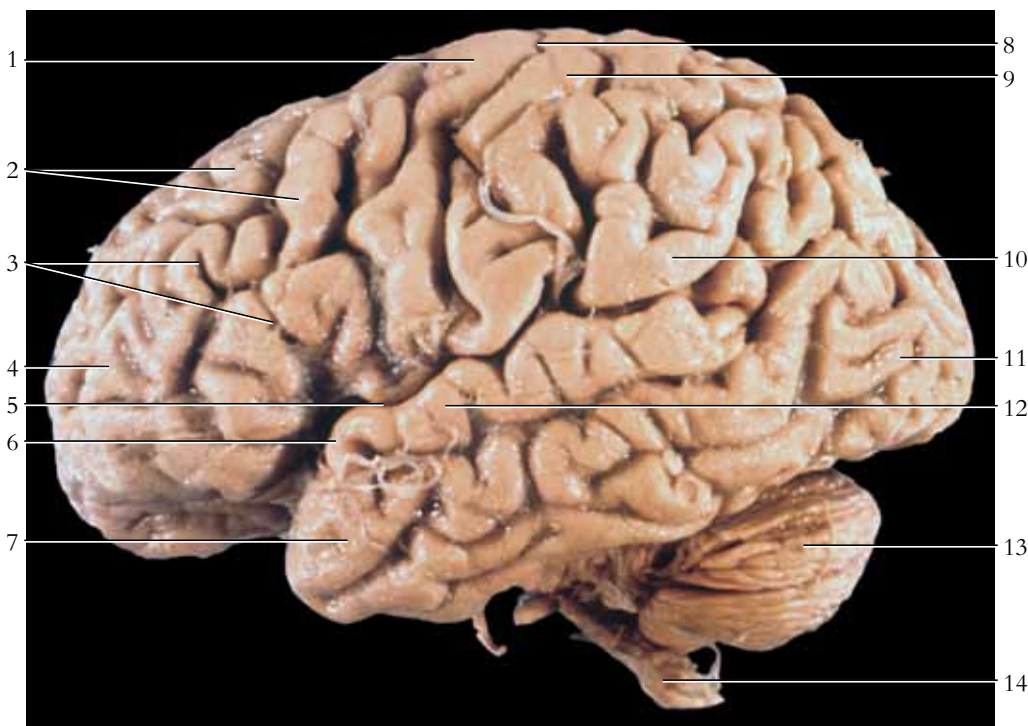
**Figure 9.7** A sectioned cranium exposing the meninges and cerebrum.

- |                                    |                                  |
|------------------------------------|----------------------------------|
| 1. Cerebral gyrus                  | 5. Cerebral cortex (gray matter) |
| 2. Arachnoid                       | 6. Skull                         |
| 3. Dura mater                      |                                  |
| 4. Cerebral medulla (white matter) |                                  |



**Figure 9.8** The relationship of the meninges to the skull and the cerebrum.

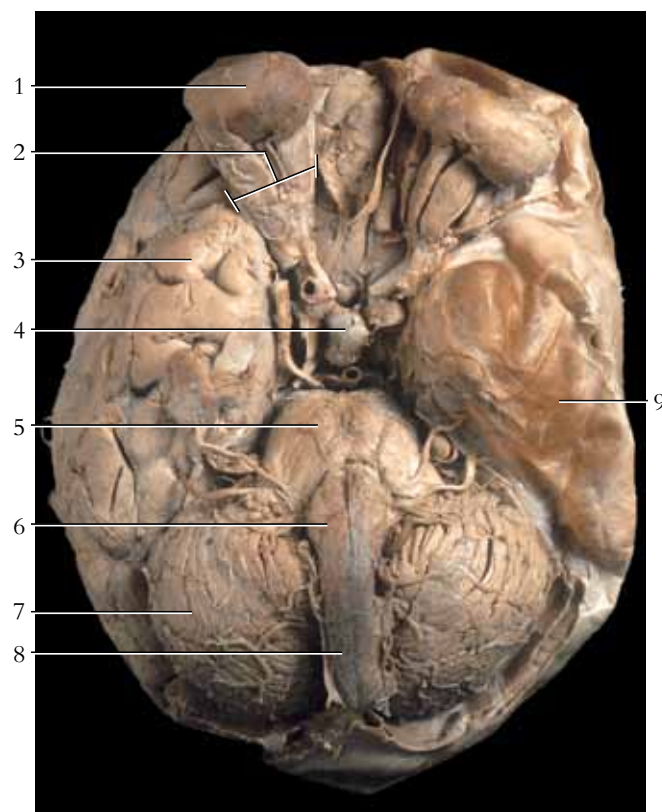
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|--------------------------|---------------------|
| 1. Subdural space        | 8. Bone of cranium  |
| 2. Subarachnoid space    | 9. Periosteal layer |
| 3. Super sagittal sinus  | 10. Meningeal layer |
| 4. Arachnoid granulation | 11. Arachnoid mater |
| 5. Falx cerebri          | 12. Pia mater       |
| 6. Skin of scalp         | 13. Blood vessel    |
| 7. Periosteum            | 14. Dura mater      |



**Figure 9.9** A lateral view of the brain.

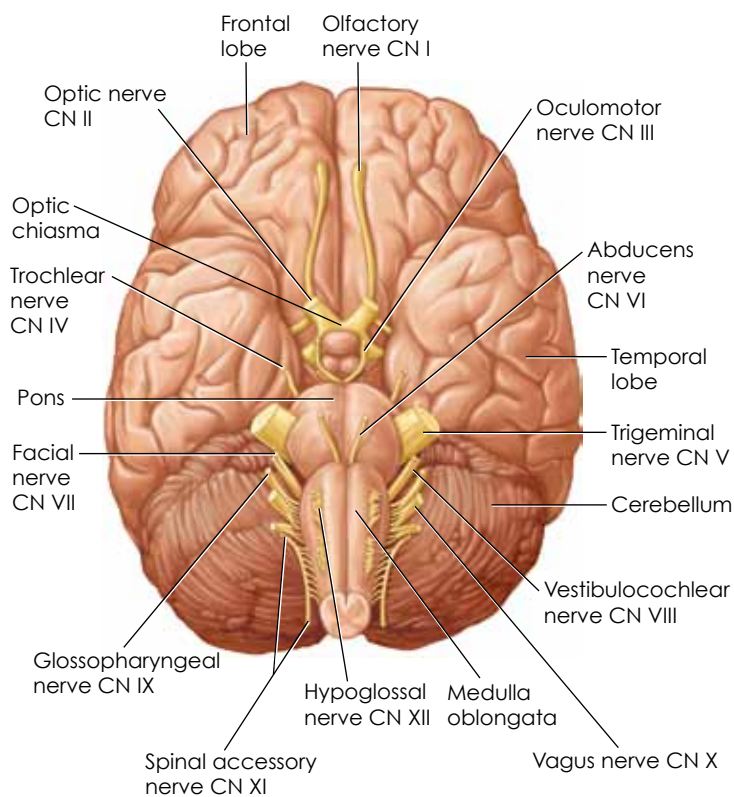
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|----------------------------------|------------------------------------|
| 1. Primary motor cerebral cortex | 8. Central sulcus                  |
| 2. Gyri                          | 9. Primary sensory cerebral cortex |
| 3. Sulci                         | 10. Parietal lobe of cerebrum      |
| 4. Frontal lobe of cerebrum      | 11. Occipital lobe of cerebrum     |
| 5. Lateral sulcus                | 12. Auditory cerebral cortex       |
| 6. Olfactory cerebral cortex     | 13. Cerebellum                     |
| 7. Temporal lobe of cerebrum     | 14. Medulla oblongata              |





**Figure 9.10** An inferior view of the brain with the eyes and part of the meninges still intact.

- |                              |                      |
|------------------------------|----------------------|
| 1. Eyeball                   | 6. Medulla oblongata |
| 2. Muscles of the eye        | 7. Cerebellum        |
| 3. Temporal lobe of cerebrum | 8. Spinal cord       |
| 4. Pituitary gland           | 9. Dura mater        |
| 5. Pons                      |                      |

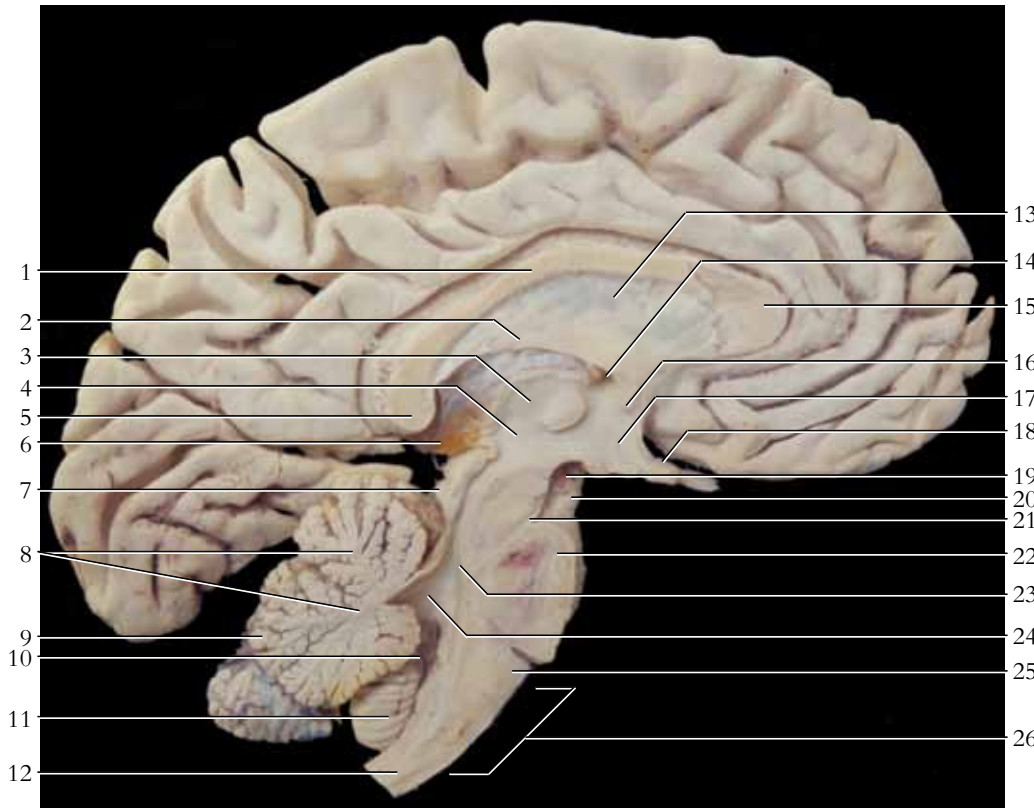


**Figure 9.11** A diagram of the inferior of the brain showing the cranial nerves.



**Figure 9.12** The cranial nerves and blood supply to the brain.

- |  |                            |
|--|----------------------------|
| 1. Internal carotid artery                     | 6. Olfactory tract         |
| 2. Cerebral arterial circle (circle of Willis) | 7. Optic nerve             |
| 3. Trigeminal nerve                            | 8. Optic chiasma           |
| 4. Abducens nerves                             | 9. Oculomotor nerve        |
| 5. Vestibulocochlear nerve                     | 10. Trochlear nerve        |
| 6. Olfactory tract                             | 11. Trigeminal nerve       |
| 7. Optic nerve                                 | 12. Facial nerve           |
| 8. Optic chiasma                               | 13. Glossopharyngeal nerve |
| 9. Oculomotor nerve                            | 14. Vagus nerve            |
| 10. Trochlear nerve                            | 15. Vertebral artery       |



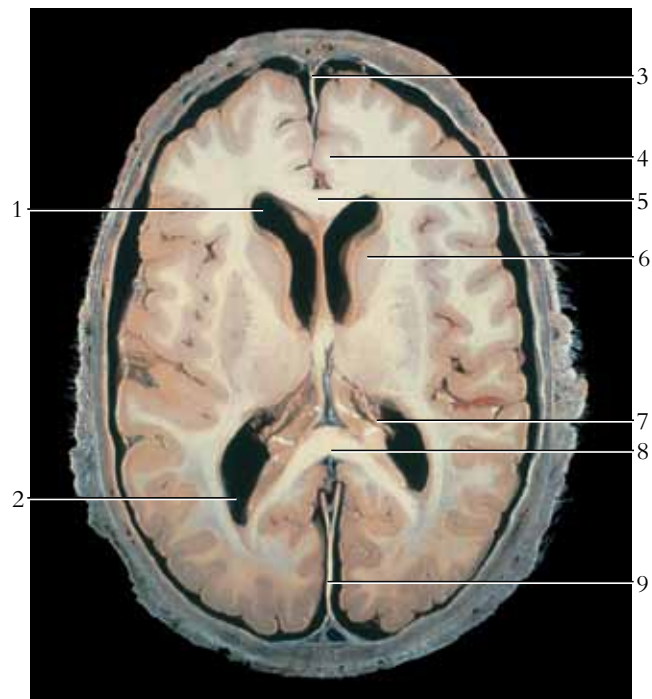
**Figure 9.13** A sagittal view of the brain.

1. Body of corpus callosum
2. Crus of fornix
3. Third ventricle
4. Posterior commissure
5. Splenium of corpus callosum
6. Pineal body
7. Inferior colliculus
8. Arbor vitae of cerebellum
9. Vermis of cerebellum
10. Choroid plexus of fourth ventricle
11. Tonsilla of cerebellum
12. Spinal cord
13. Septum pellucidum
14. Intraventricular foramen
15. Genu of corpus callosum
16. Anterior commissure
17. Hypothalamus
18. Optic chiasma
19. Oculomotor nerve
20. Cerebral peduncle
21. Midbrain
22. Pons
23. Mesencephalic (cerebral) aqueduct
24. Fourth ventricle
25. Pyramid of medulla oblongata
26. Medulla oblongata



**Figure 9.14** A transaxial section of the skull and brain.

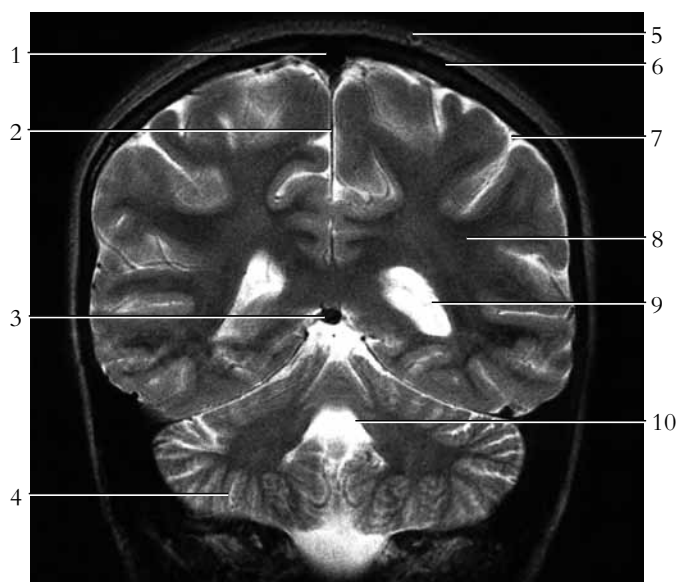
1. Falx cerebri (septum of dura matter)
2. Sulcus
3. Gyrus
4. Subdural space
5. Mesencephalic aqueduct (cerebral aqueduct)
6. Cerebellum
7. Cerebral cortex (gray matter)
8. Cerebral medulla (white matter)
9. Frontal lobe
10. Insula
11. Temporal lobe
12. Occipital lobe



**Figure 9.15** A transaxial section of the skull and brain.

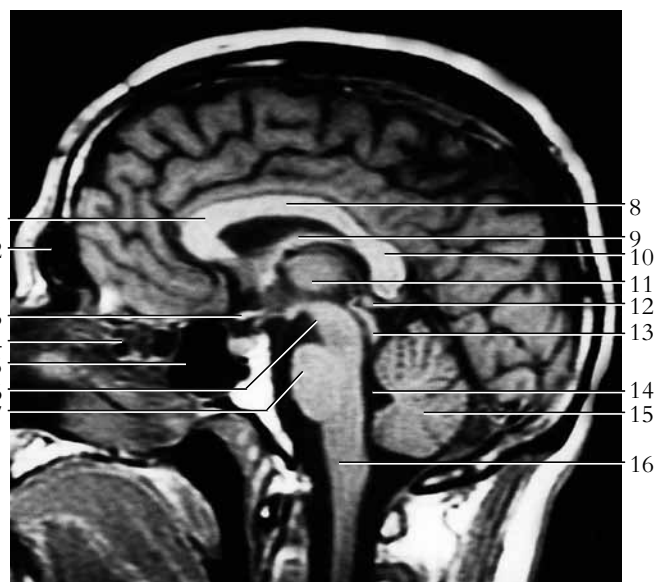
1. Anterior horn of lateral ventricle
2. Posterior horn of lateral ventricle
3. Falx cerebri (septum of dura mater)
4. Cingulate gyrus
5. Genu of corpus callosum
6. Caudate nucleus
7. Choroid plexus
8. Splenium of corpus callosum
9. Falx cerebri (septum of dura mater)





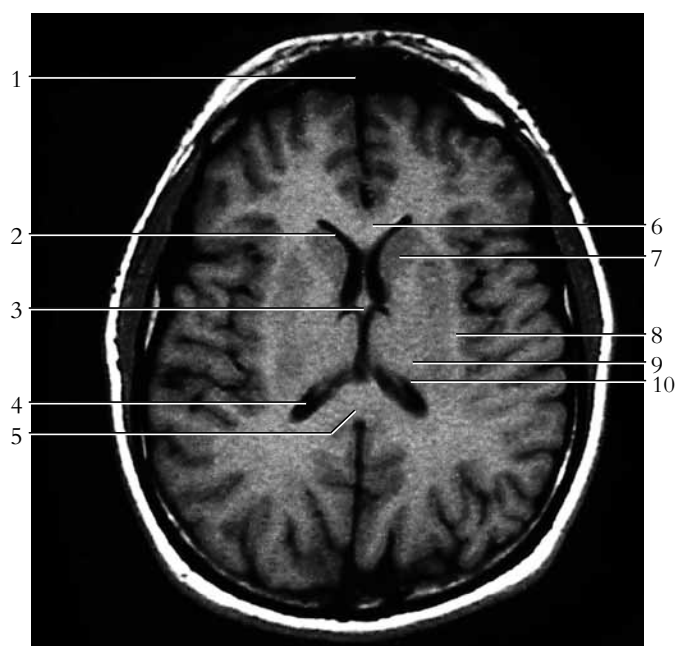
**Figure 9.16** A coronal MRI brain scan.

- |                                  |                      |
|----------------------------------|----------------------|
| 1. Cerebrospinal fluid           | 6. Dura mater        |
| 2. Longitudinal cerebral fissure | 7. Cerebral cortex   |
| 3. Third ventricle               | 8. Cerebral medulla  |
| 4. Cerebellum                    | 9. Lateral ventricle |
| 5. Skull                         | 10. Fourth ventricle |



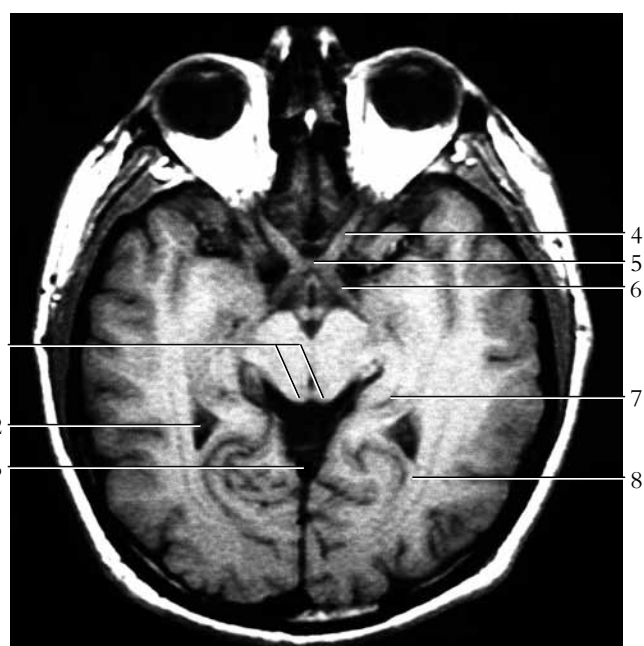
**Figure 9.17** An MRI sagittal section through the skull.

- |                            |                                     |
|----------------------------|-------------------------------------|
| 1. Genu of corpus callosum | 10. Splenium of corpus callosum     |
| 2. Frontal sinus           | 11. Thalamus                        |
| 3. Pituitary gland         | 12. Pineal gland                    |
| 4. Ethmoidal sinus         | 13. Superior and inferior colliculi |
| 5. Sphenoidal sinus        | 14. Fourth ventricle                |
| 6. Tegmentum (midbrain)    | 15. Cerebellum                      |
| 7. Pons                    | 16. Medulla oblongata               |
| 8. Body of corpus callosum |                                     |
| 9. Fornix                  |                                     |



**Figure 9.18** An MRI transaxial section through the brain.

- |  |                                |
|--|--------------------------------|
| 1. Frontal sinus                       | 5. Splenium of corpus callosum |
| 2. Frontal horn of lateral ventricle   | 6. Genu of corpus callosum     |
| 3. Body of fornix                      | 7. Head of caudate nucleus     |
| 4. Posterior horn of lateral ventricle | 8. External capsule            |
|  | 9. Thalamus                    |
|  | 10. Choroid plexus             |



**Figure 9.19** An MRI transaxial section showing visual pathways.

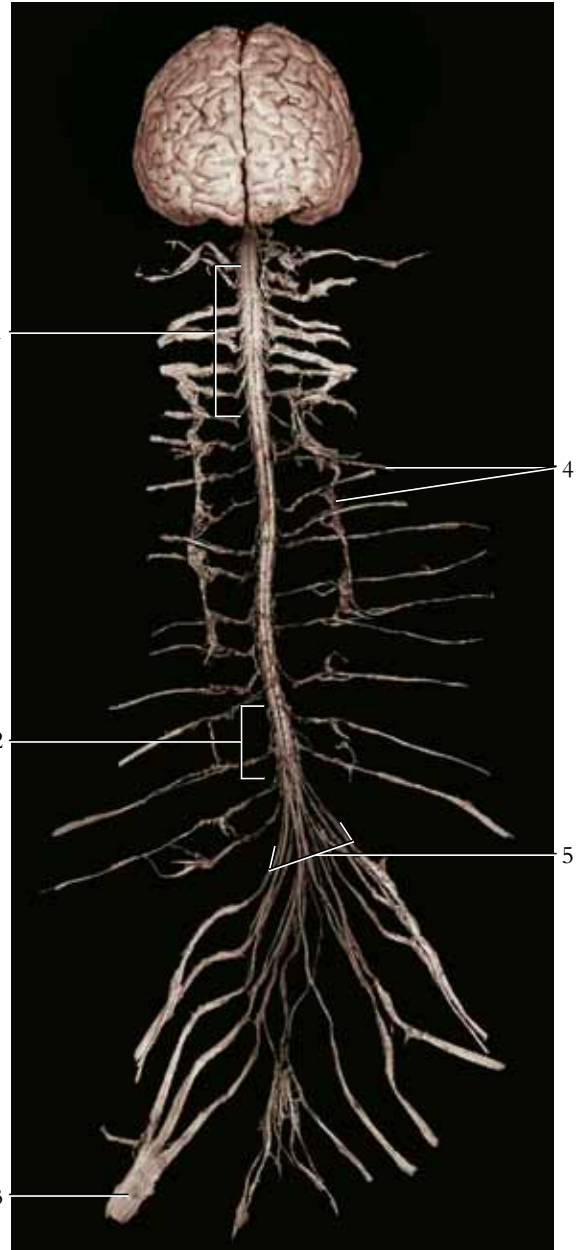
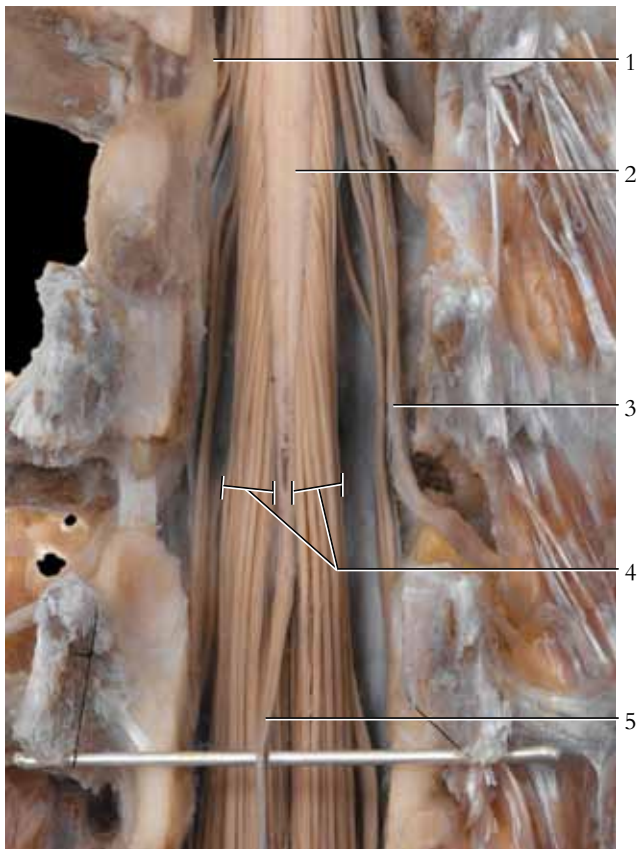
- |                       |                                       |
|-----------------------|---------------------------------------|
| 1. Superior colliculi | 6. Optic tract                        |
| 2. Lateral ventricle  | 7. Lateral geniculate body            |
| 3. Third ventricle    | 8. Calcarine tracts (optic radiation) |
| 4. Optic nerve        |                                       |
| 5. Optic chiasma      |                                       |





**Figure 9.20** A MRI coronal section through the thalamus.

1. Superior sagittal sinus
2. Lateral ventricle
3. Lateral fissure
4. Corpus callosum
5. Thalamus
6. Third ventricle

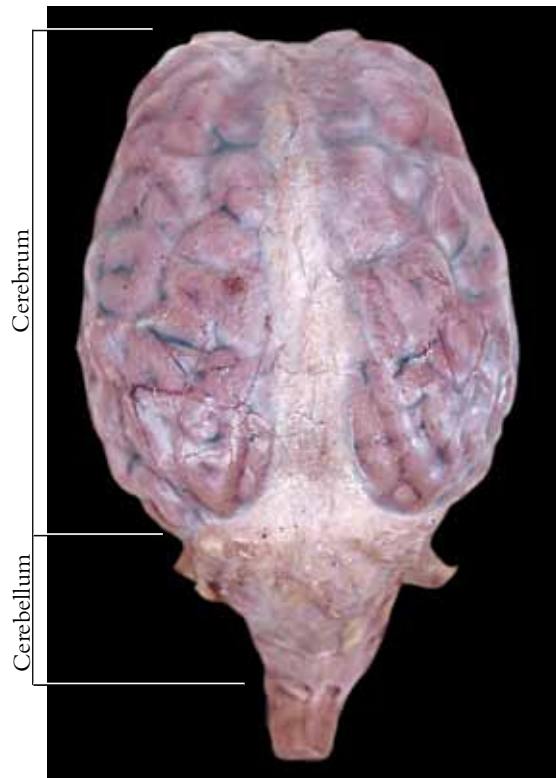


**Figure 9.21** The anterior surface of the brain and spinal cord with meninges removed.

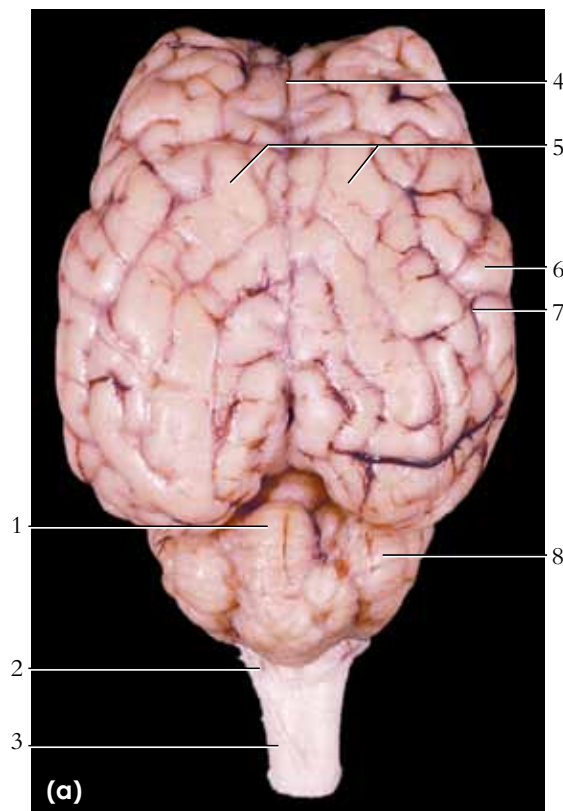
1. Cervical enlargement
2. Lumbar enlargement
3. Sciatic nerve
4. Sympathetic ganglia
5. Cauda equina

**Figure 9.22** A posterior view of the lower spinal cord.

1. Dura mater (cut)
2. Spinal cord
3. Posterior (dorsal) root of spinal nerve
4. Cauda equina
5. Filum terminale

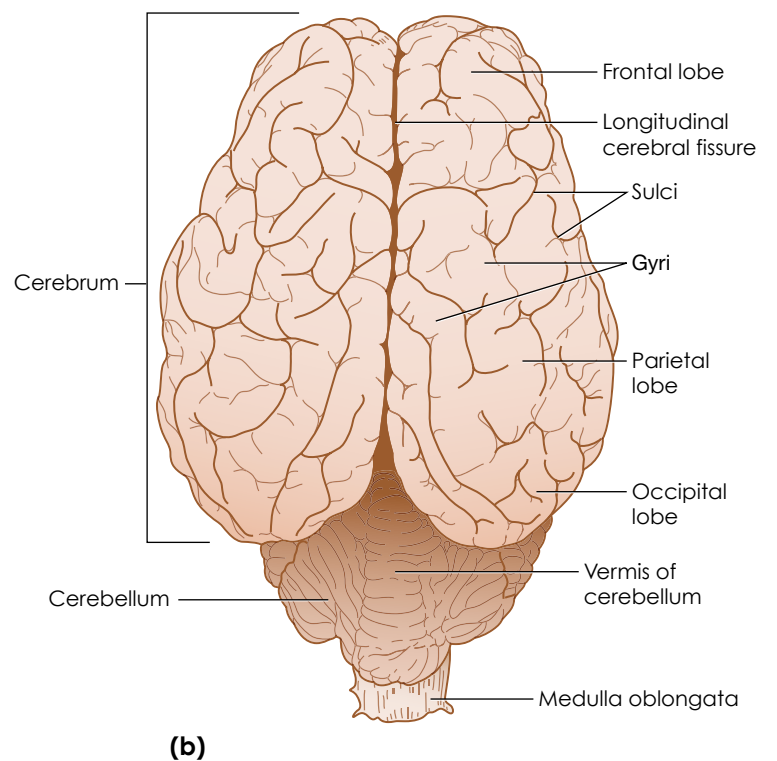


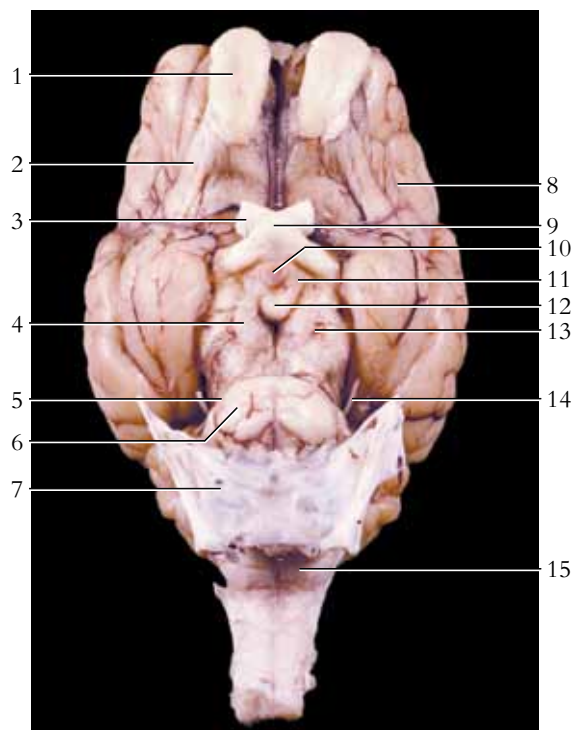
**Figure 9.23** A dorsal view of the sheep brain.



**Figure 9.24** A dorsal view of the sheep brain, (a) photograph; (b) diagram.

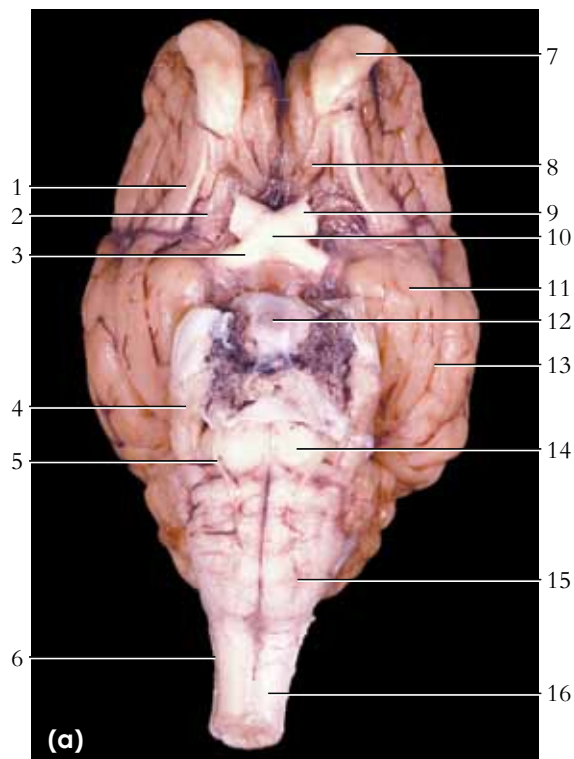
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|----------------------------------|--------------------------|
| 1. Vermis                        | 5. Cerebral hemispheres  |
| 2. Medulla oblongata             | 6. Gyrus                 |
| 3. Spinal Cord                   | 7. Sulcus                |
| 4. Longitudinal cerebral fissure | 8. Cerebellar hemisphere |





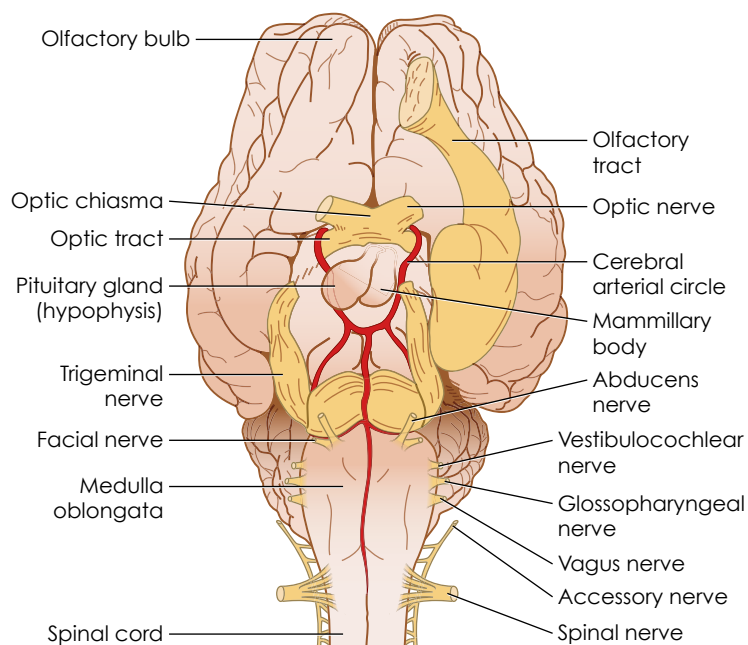
**Figure 9.25** A ventral view of sheep brain with dura mater cut and reflected.

1. Olfactory bulb
2. Olfactory tract
3. Optic nerve
4. Oculomotor nerve
5. Trigeminal nerve
6. Pons
7. Dura mater (cut)
8. Pia mater (adhering to brain)
9. Optic chiasma
10. Position of pituitary stock
11. Tuber cinereum
12. Mammillary body
13. Cerebral penduncle
14. Trochlear nerve
15. Medulla oblongata



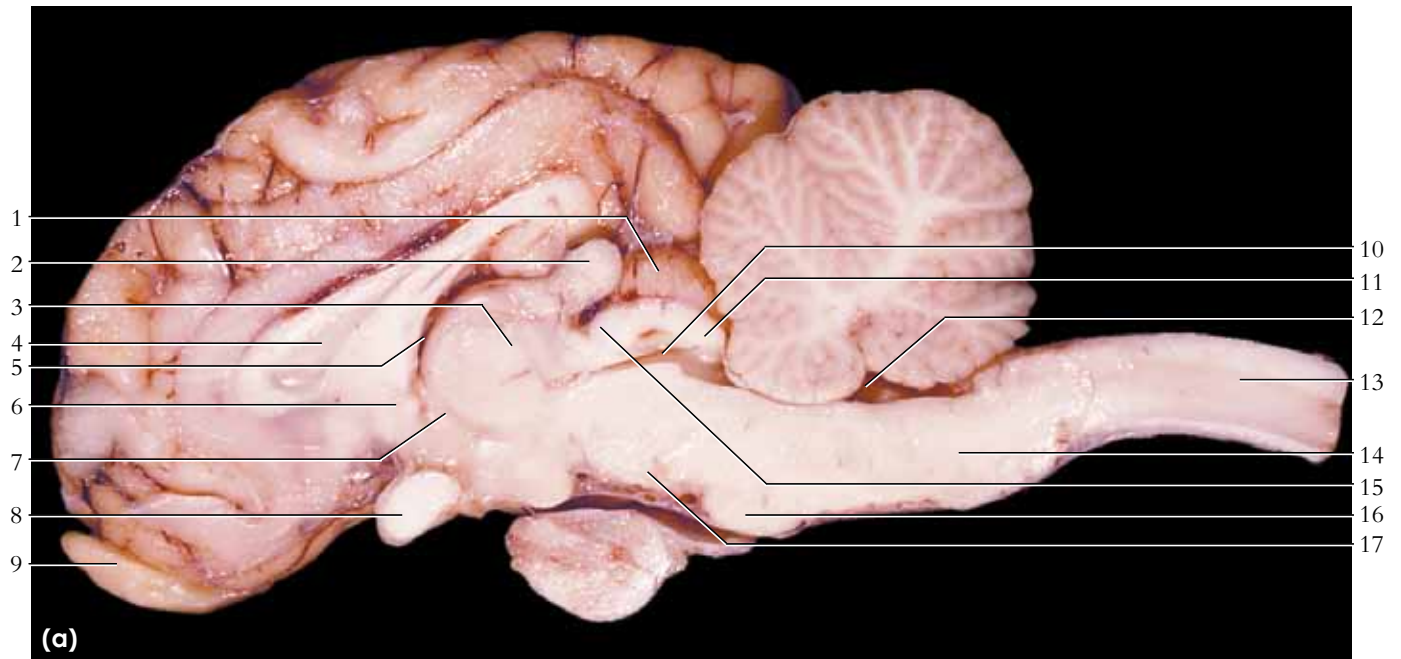
**Figure 9.26** A ventral view of sheep brain, (a) photograph and (b) diagram.

1. Lateral olfactory band
2. Olfactory trigone
3. Optic tract
4. Trigeminal nerve
5. Abducens nerve
6. Accessory nerve
7. Olfactory bulb
8. Medial olfactory band
9. Optic nerve
10. Optic chiasma
11. Pyriform lobe
12. Pituitary gland (hypophysis)
13. Rhinal sulcus
14. Pons
15. Medulla oblongata
16. Spinal cord



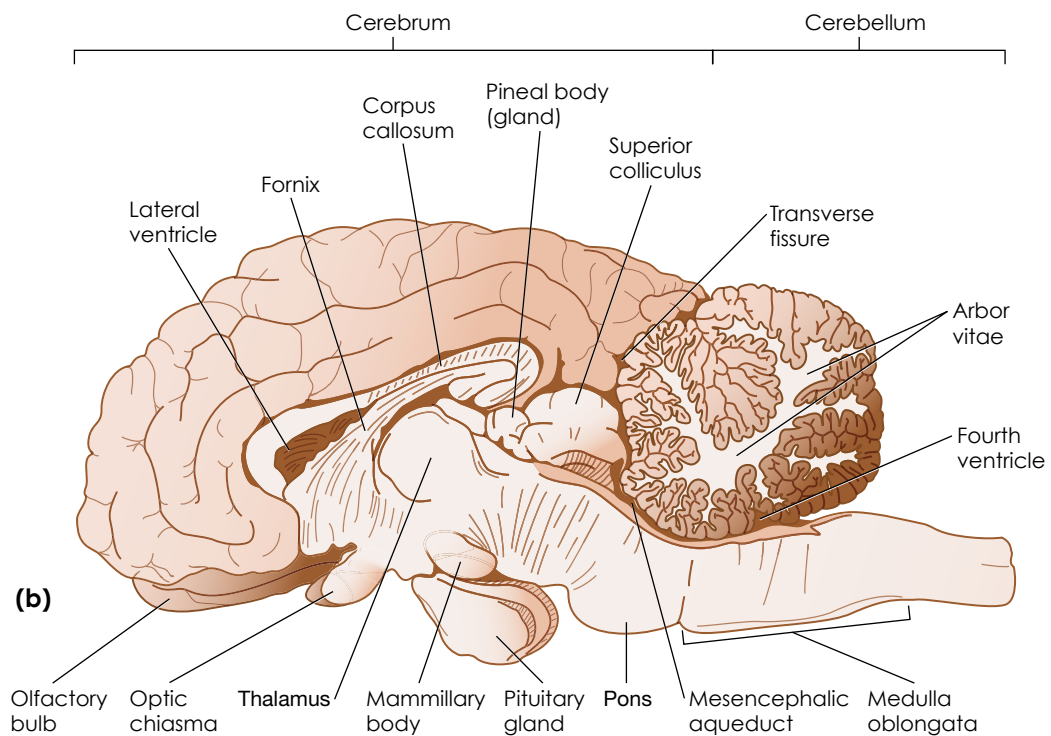
**(b)**

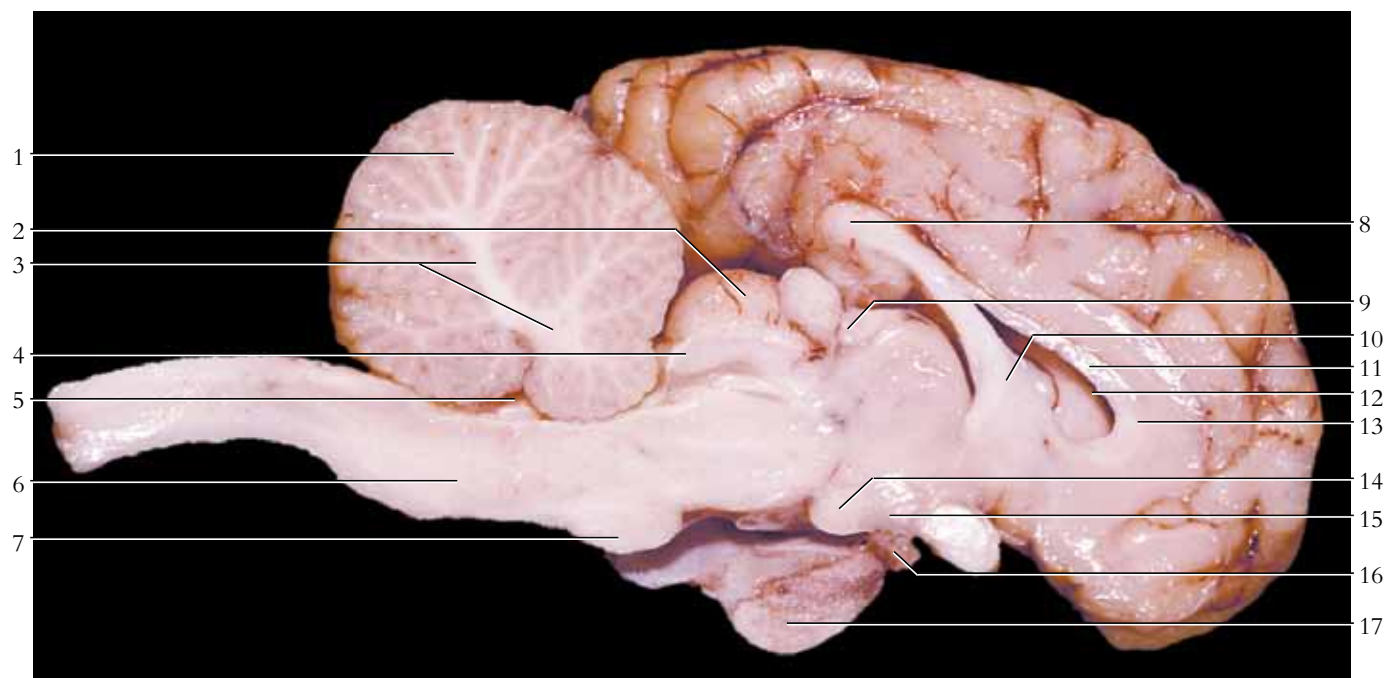




**Figure 9.27** A right sagittal view of the sheep brain, (a) photograph and (b) diagram.

- |   |                                       |                          |
|---|---------------------------------------|--------------------------|
| 1. Superior colliculus                            | 7. Third ventricle                    | 14. Medulla oblongata    |
| 2. Pineal body (gland)                            | 8. Optic chiasma                      | 15. Posterior commissure |
| 3. Intermediate mass                              | 9. Olfactory bulb                     | 16. Pons                 |
| 4. Septum pellucidum                              | 10. Mesencephalic (cerebral) aqueduct | 17. Cerebral peduncle    |
| 5. Interventricular foramen<br>(foramen of Monro) | 11. Inferior colliculus               |                          |
| 6. Anterior commissure                            | 12. Fourth ventricle                  |                          |
|   | 13. Spinal cord                       |                          |



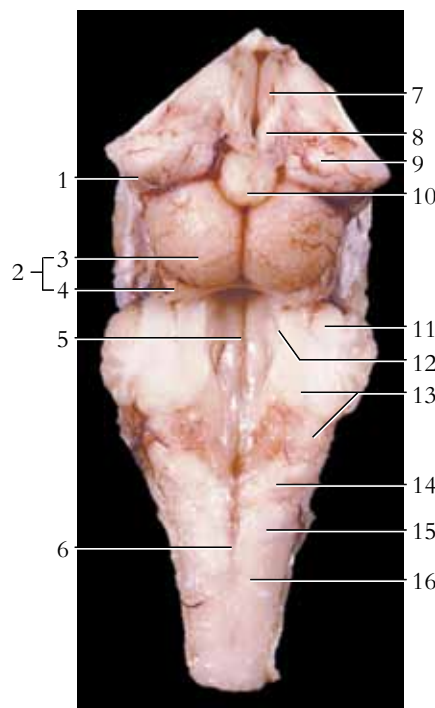
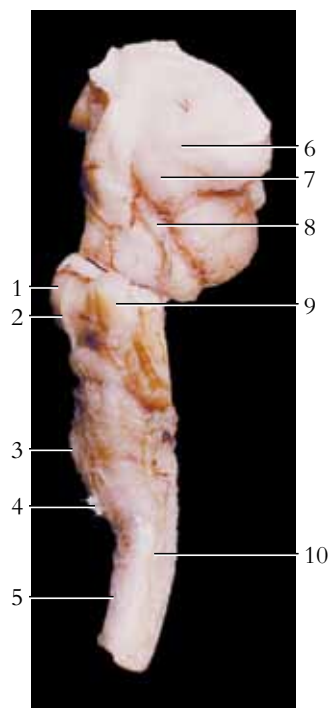


**Figure 9.28** A left sagittal view of the sheep brain.

- |                        |                                |                                  |
|------------------------|--------------------------------|----------------------------------|
| 1. Cerebellum          | 7. Pons                        | 13. Genu of corpus callosum      |
| 2. Superior colliculus | 8. Splenium of corpus callosum | 14. Mammillary body              |
| 3. Arbor vitae         | 9. Habenular trigone           | 15. Tuber cinereum               |
| 4. Inferior colliculus | 10. Fornix                     | 16. Pituitary stalk              |
| 5. Fourth ventricle    | 11. Body of corpus callosum    | 17. Pituitary gland (hypophysis) |
| 6. Medulla oblongata   | 12. Lateral ventricle          |                                  |

**Figure 9.29** A lateral view of the brainstem.

1. Pons
2. Abducens nerve
3. Medulla oblongata
4. Hypoglossal nerve
5. Spinal cord
6. Lateral geniculate body
7. Medial geniculate body
8. Trochlear nerve
9. Trigeminal nerve
10. Accessory nerve



**Figure 9.30** A dorsal view of the brainstem.

1. Medial geniculate body
2. Corpora quadrigemina
3. Superior colliculus
4. Inferior colliculus
5. Fourth ventricle
6. Dorsal median sulcus
7. Intermediate mass
8. Habenular trigone
9. Thalamus
10. Pineal gland
11. Middle cerebellar peduncle
12. Anterior cerebellar peduncle
13. Posterior cerebellar peduncle
14. Tuberculum cuneatum
15. Fasciculus gracilis
16. Fasciculus cuneatus

# Chapter 10

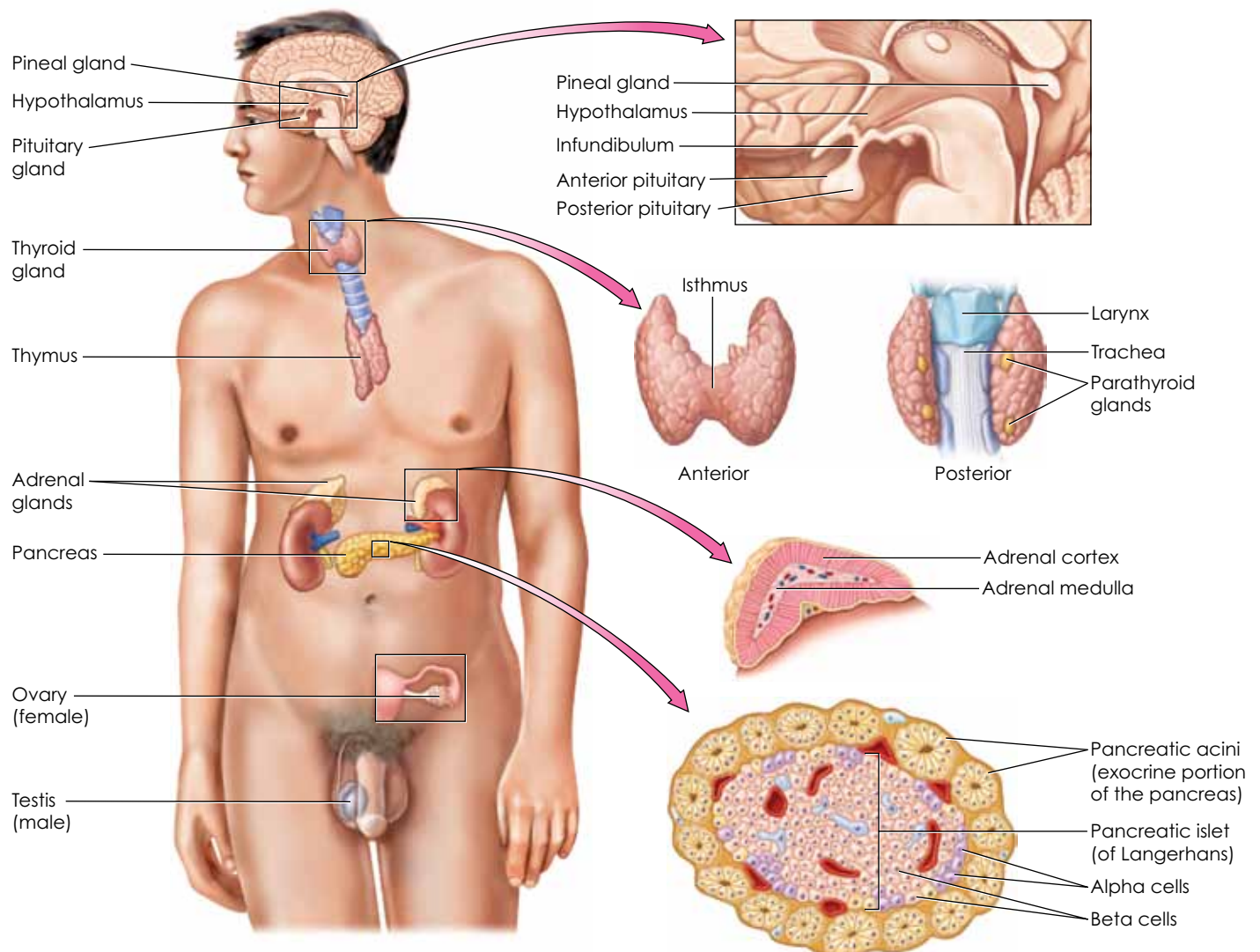
## Endocrine System

The endocrine system works closely with the nervous system to regulate and integrate body processes and maintain homeostasis. The nervous system regulates body activities through the action of electrochemical impulses that are transmitted by means of neurons, resulting in rapid, but usually brief responses. By contrast, the endocrine system is composed of glands (fig. 10.1) scattered throughout the body that release chemical substances called **hormones** into the bloodstream. These hormones dissipate in the blood and travel throughout the entire body to act on **target tissues**, where they have a slow but relatively long-lasting effect. Neurological responses are measured in milliseconds, but hormonal action requires seconds or days to elicit a response. Some hormones may have an effect that lasts for minutes and others for weeks or months.

The endocrine system and nervous system are closely coordinated in autonomically controlling the functions of the

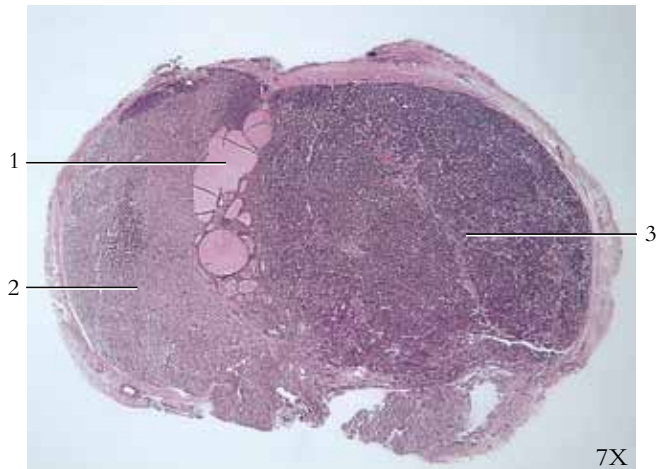
body. The **pituitary gland**, located in the brain, regulates the activity of most other endocrine glands. Located immediately between the pituitary and the rest of the brain is the **hypothalamus**. The hypothalamus serves as an intermediate between the nervous centers of the brain and the pituitary gland, correlating the activity of the two systems. Furthermore, certain hormones may stimulate or inhibit the activities of the nervous system.

Other organs of the endocrine system include the **thyroid gland** and **parathyroid glands**, located in the neck. The **adrenal glands** and **pancreas** are located in the abdominal region. The **ovaries** of the female are located in the pelvic cavity, whereas the **testes** of the male are located in the scrotum. Even the **placenta** serves as an endocrine organ for the developing fetus and has some hormonal influence upon the pregnant woman.



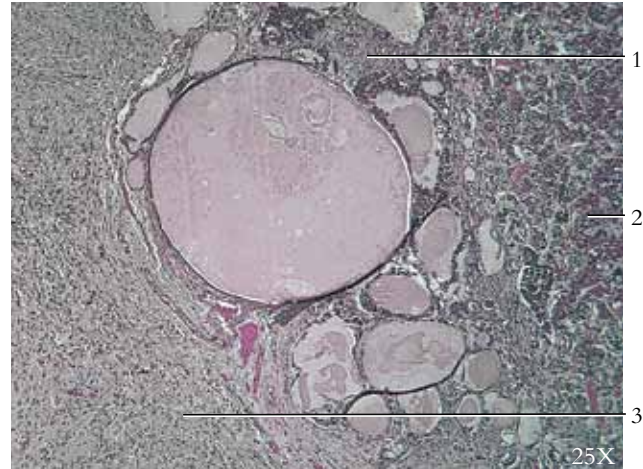
**Figure 10.1** The principal glands of the endocrine system.





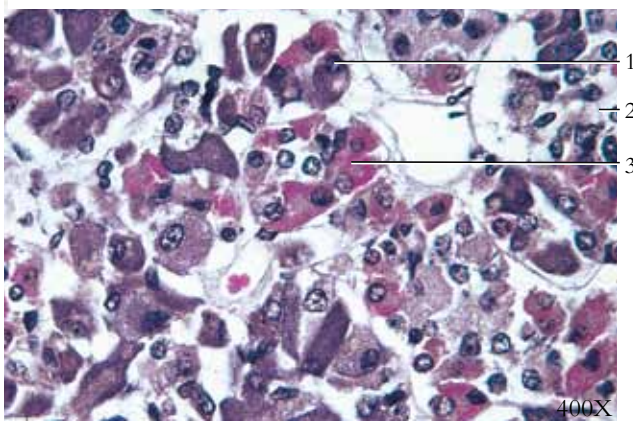
**Figure 10.2** Pituitary gland.

1. Pars intermedia (adenohypophysis)
2. Pars nervosa (neurohypophysis)
3. Pars distalis (adenohypophysis)



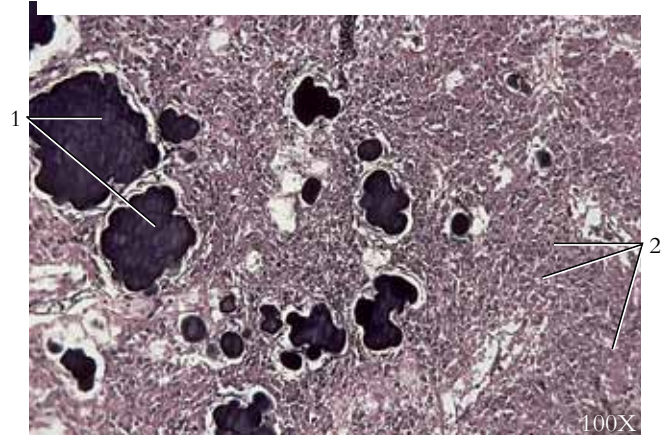
**Figure 10.3** Pituitary gland.

1. Pars intermedia
2. Pars distalis
3. Pars nervosa



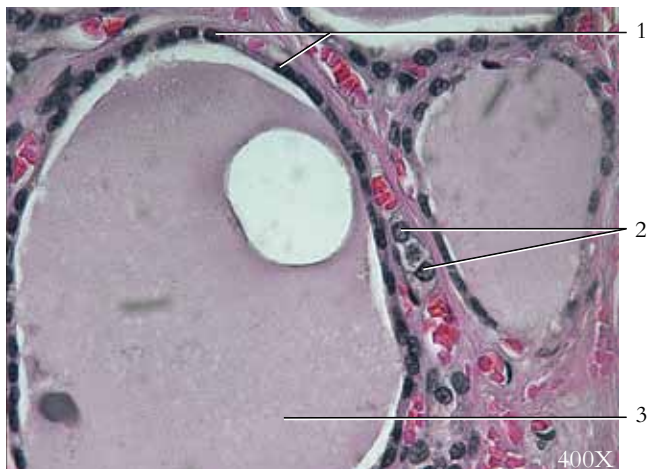
**Figure 10.4** Pars distalis of the pituitary gland.

1. Basophil
2. Chromophobe
3. Acidophil



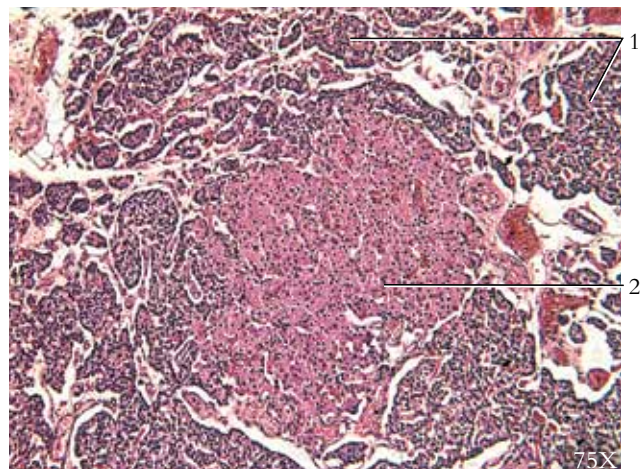
**Figure 10.5** Pineal gland.

1. Brain sand
2. Pinealocytes



**Figure 10.6** Thyroid gland.

1. Follicle cells
2. C cells
3. Colloid within follicle



**Figure 10.7** Parathyroid gland.

1. Chief cells
2. Cluster of oxyphil cells





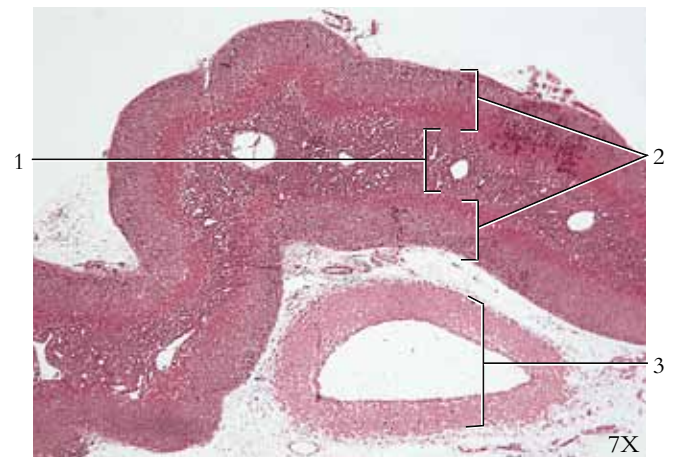
**Figure 10.8** The adrenal (suprarenal) gland and pancreas with associated structures within the abdominal cavity with overlying viscera removed.

1. Liver (reflected)
2. Stomach (reflected)
3. Pancreas
4. Duodenum
5. Diaphragm
6. Spleen
7. Adrenal gland
8. Kidney



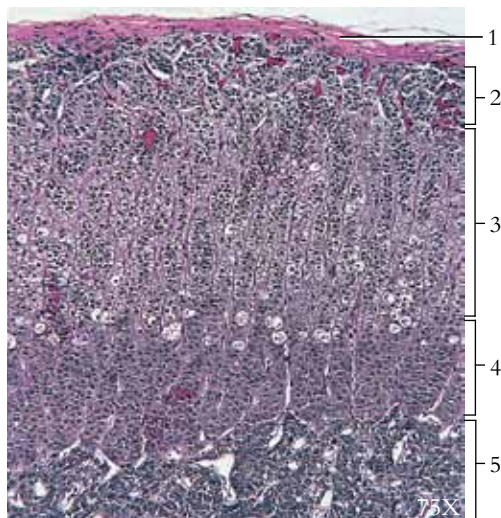
**Figure 10.9** The adrenal gland.

1. Adrenal gland
2. Inferior suprarenal artery
3. Kidney



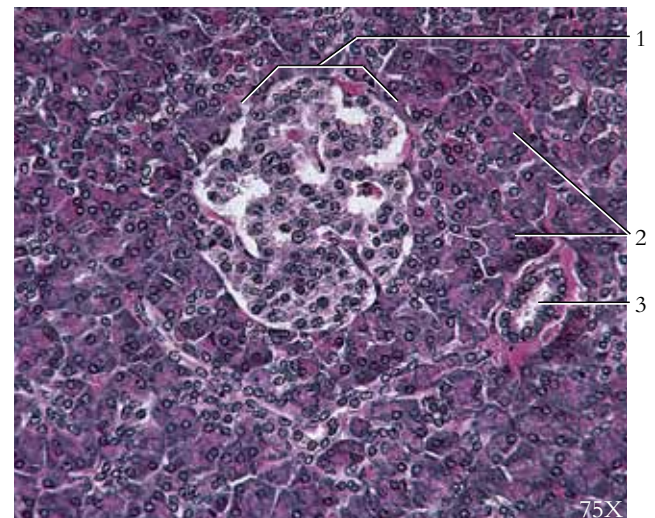
**Figure 10.10** Adrenal gland.

1. Adrenal medulla
2. Adrenal cortex
3. Blood vessel



**Figure 10.11** Adrenal gland.

1. Capsule
2. Zona glomerulosa (adrenal cortex)
3. Zona fasciculata (adrenal cortex)
4. Zona reticularis (adrenal cortex)
5. Adrenal medulla



**Figure 10.12** Pancreatic islet (islet of Langerhans).

1. Pancreatic islet (endocrine pancreas)
2. Acini (exocrine pancreas)
3. Pancreatic duct (exocrine pancreas)

# Chapter 11

## Sensory Organs

The nervous and endocrine systems convey information from the brain to all parts of the body to enable a person to interact with both the external and internal environments and to maintain homeostasis. The sense organs, in contrast, convey information from the outside world (and inside world of the body) back to the brain. This includes a wide range of information such as temperature, brightness, sound, flavor, and balance.

The sense organs are actually extensions of the nervous system that allow us to autonomously respond or conscientiously perceive our internal and external environments. A stimulus excites a sense organ which then transduces the stimulus to an electrical (nerve) impulse. Sensory nerves transmit the impulse (sensation) to the brain to be perceived and acted upon. Ultimately, it is the brain which actually feels, sees, hears, tastes, and smells.

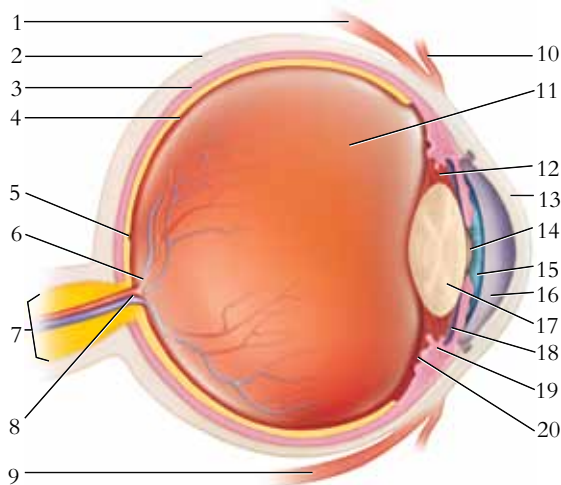
The **eyes** are the organs of visual sense. The eyes refract (bend) and focus the incoming light waves onto the sensitive **photoreceptors (rods and cones)** at the back of each eye. Nerve impulses from the stimulated photoreceptors are conveyed along visual pathways to the occipital lobes of the cerebrum, where visual sensations are perceived.

The eyeball consists of the fibrous tunic, which is divided into the **sclera** and **cornea**; the vascular tunic, which consists

of the **choroid**, the **ciliary body**, and the **iris**; and the internal tunic, or **retina**, which consists of an outer pigmented layer and an inner nervous layer. The eye contains an anterior cavity between the lens and the cornea. The anterior cavity is subdivided into an anterior chamber in front of the iris and a posterior chamber behind the iris. **Aqueous humor** fills both of these chambers. The posterior cavity (also called the vitreous chamber) contains vitreous humor and is located between the lens and the retina.

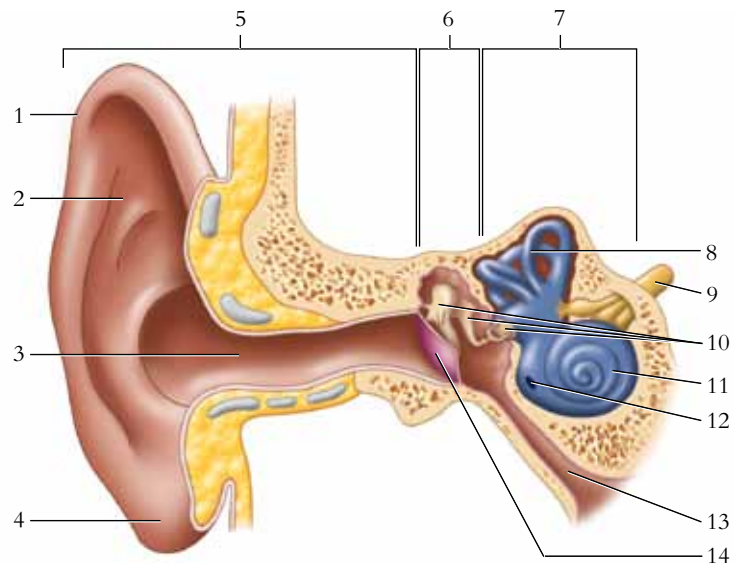
The **ear** is the organ of hearing and equilibrium (balance). It contains receptors that respond to movements of the head and receptors that convert sound waves into nerve impulses. Impulses from both receptor types are transmitted through the vestibulocochlear (VIII) cranial nerve to the brain for interpretation.

The ear consists of the three principal regions: the **outer ear**, the **middle ear**, and the **inner ear**. The outer ear consists of the **auricle** and the **external auditory canal**. The middle ear contains the auditory ossicles (**malleus**, **incus**, and **stapes**). The inner ear contains the **spiral organ** (organ of Corti) in the **cochlea** for hearing, and the **semicircular canals** and the vestibular organs for equilibrium.



**Figure 11.1** The structure of the eye.

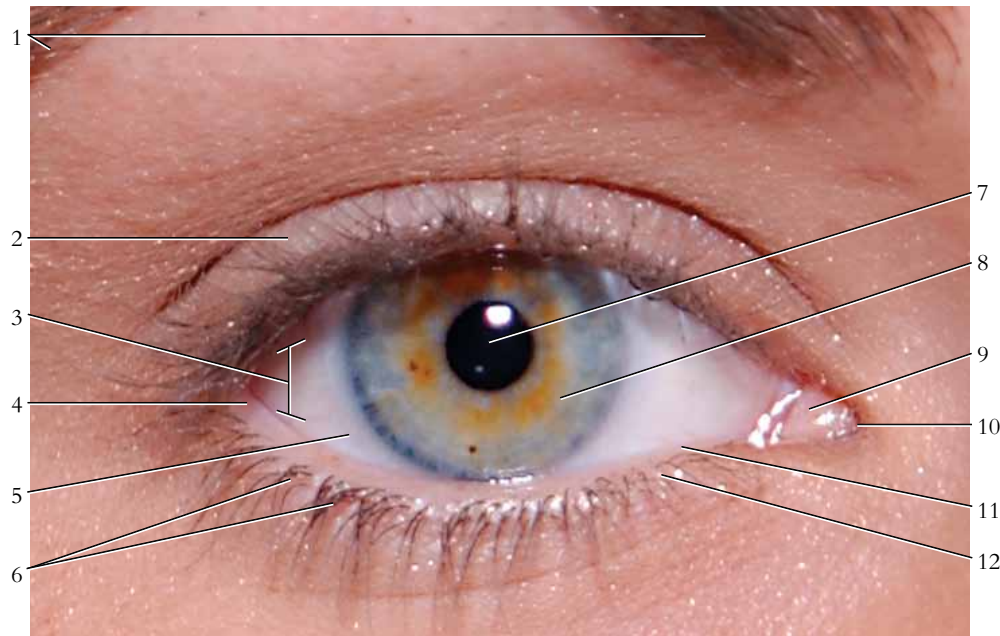
- |   |                         |
|---|-------------------------|
| 1. Superior rectus m.                             | 12. Suspensory ligament |
| 2. Sclera   | 13. Cornea              |
| 3. Choroid  | 14. Pupil               |
| 4. Retina   | 15. Iris                |
| 5. Fovea centralis                                | 16. Anterior chamber    |
| 6. Central vessels                                | 17. Lens                |
| 7. Optic nerve                                    | 18. Posterior chamber   |
| 8. Optic disc                                     | 19. Ciliary body        |
| 9. Inferior rectus m.                             | 20. Ora serrata         |
| 10. Conjunctiva                                   |                         |
| 11. Posterior cavity<br>(contains vitreous humor) |                         |



**Figure 11.2** The structure of the ear.

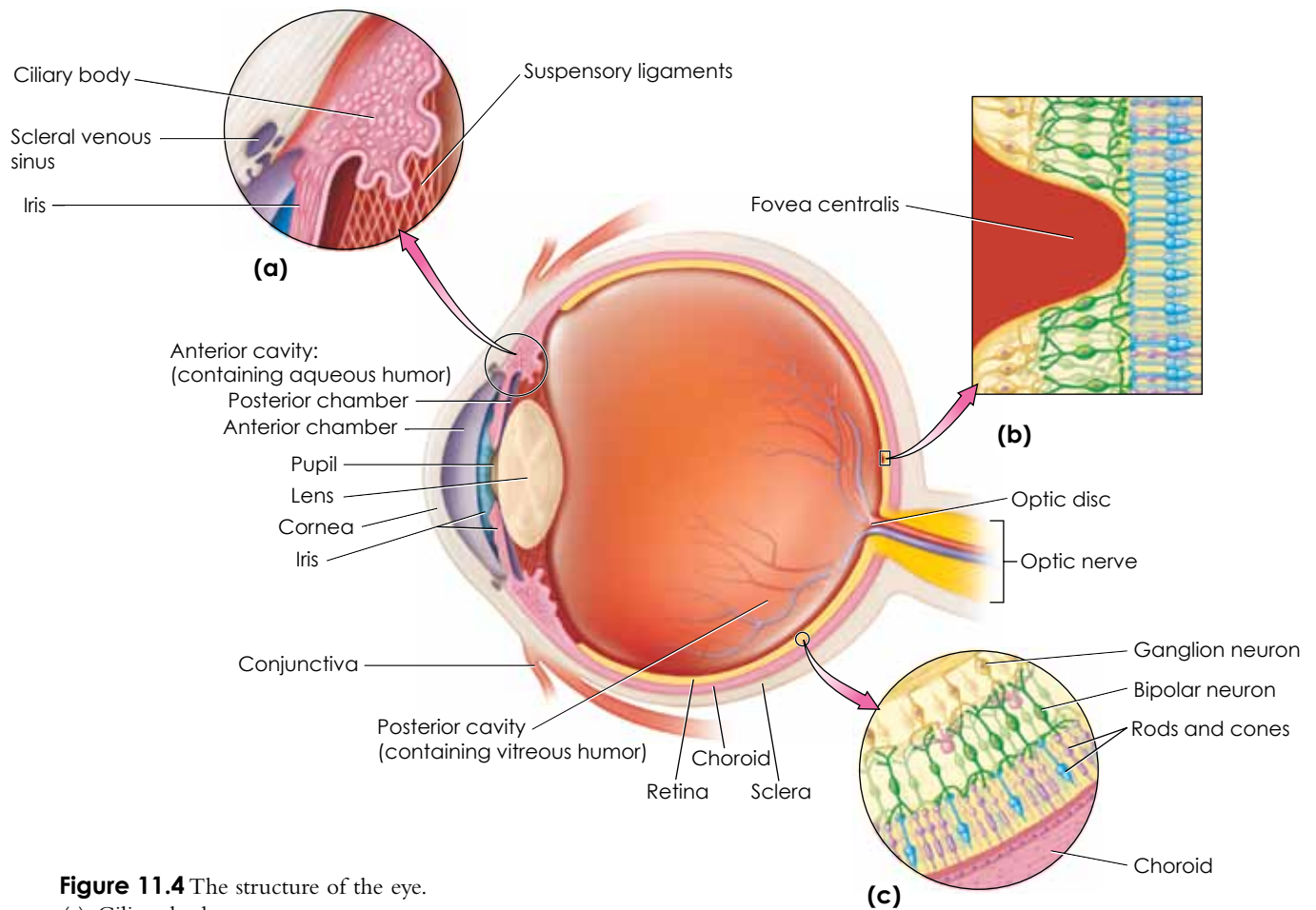
- |                            |                            |
|----------------------------|----------------------------|
| 1. Helix                   | 8. Semicircular canals     |
| 2. Auricle                 | 9. Vestibulocochlear nerve |
| 3. External auditory canal | 10. Auditory ossicles      |
| 4. Earlobe                 | 11. Cochlea                |
| 5. Outer ear               | 12. Round window           |
| 6. Middle ear              | 13. Auditory tube          |
| 7. Inner ear               | 14. Tympanic membrane      |





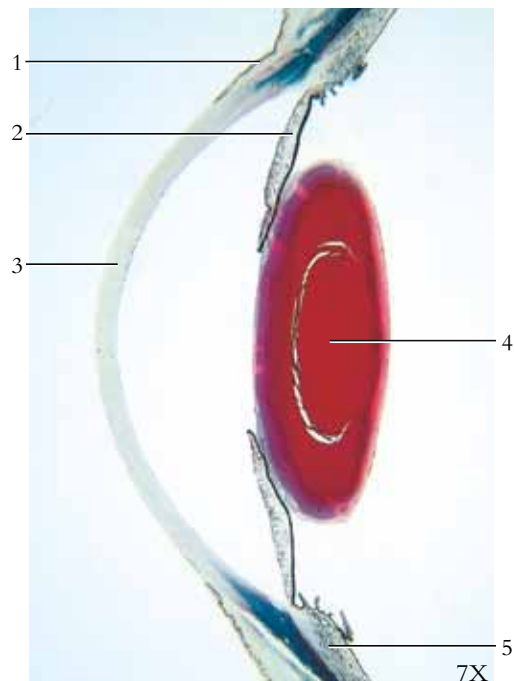
**Figure 11.3** The surface anatomy of the eye.

1. Eyebrow
2. Superior eyelid (palpebra)
3. Palpebra commissure
4. Lateral canthus
5. Sclera
6. Eyelashes
7. Pupil
8. Iris
9. Lacrimal caruncle
10. Medial commissure
11. Conjunctiva
12. Inferior eyelid (palpebra)



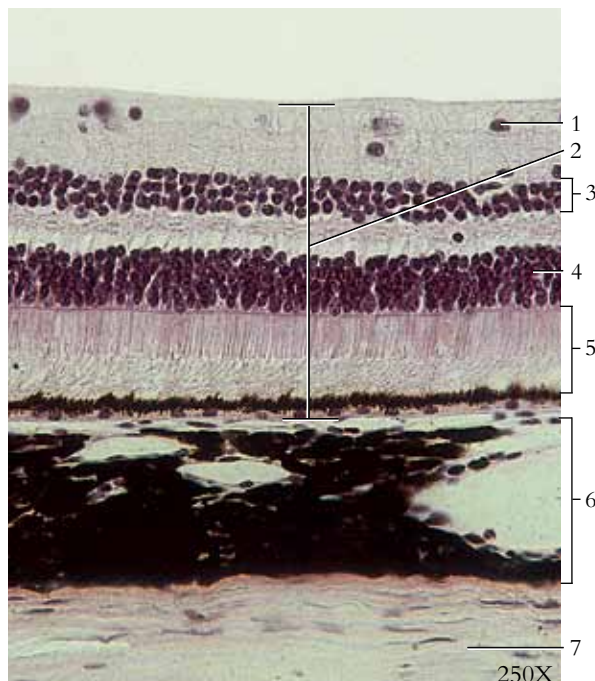
**Figure 11.4** The structure of the eye.

- (a) Ciliary body
- (b) Fovea centralis
- (c) Retina and choroid



**Figure 11.5** Anterior portion of the eye.

- |                |                 |
|----------------|-----------------|
| 1. Conjunctiva | 4. Lens         |
| 2. Iris        | 5. Ciliary body |
| 3. Cornea      |                 |



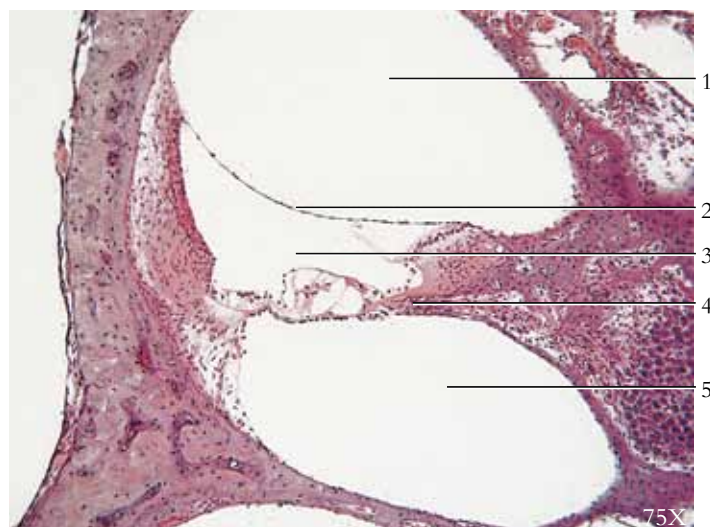
**Figure 11.6** Retina.

- |                          |                   |
|--------------------------|-------------------|
| 1. Ganglion nucleus      | 5. Rods and cones |
| 2. Retina                | 6. Choroid        |
| 3. Bipolar nuclei        | 7. Sclera         |
| 4. Rods and cones nuclei |                   |



**Figure 11.7** The surface anatomy of the auricle.

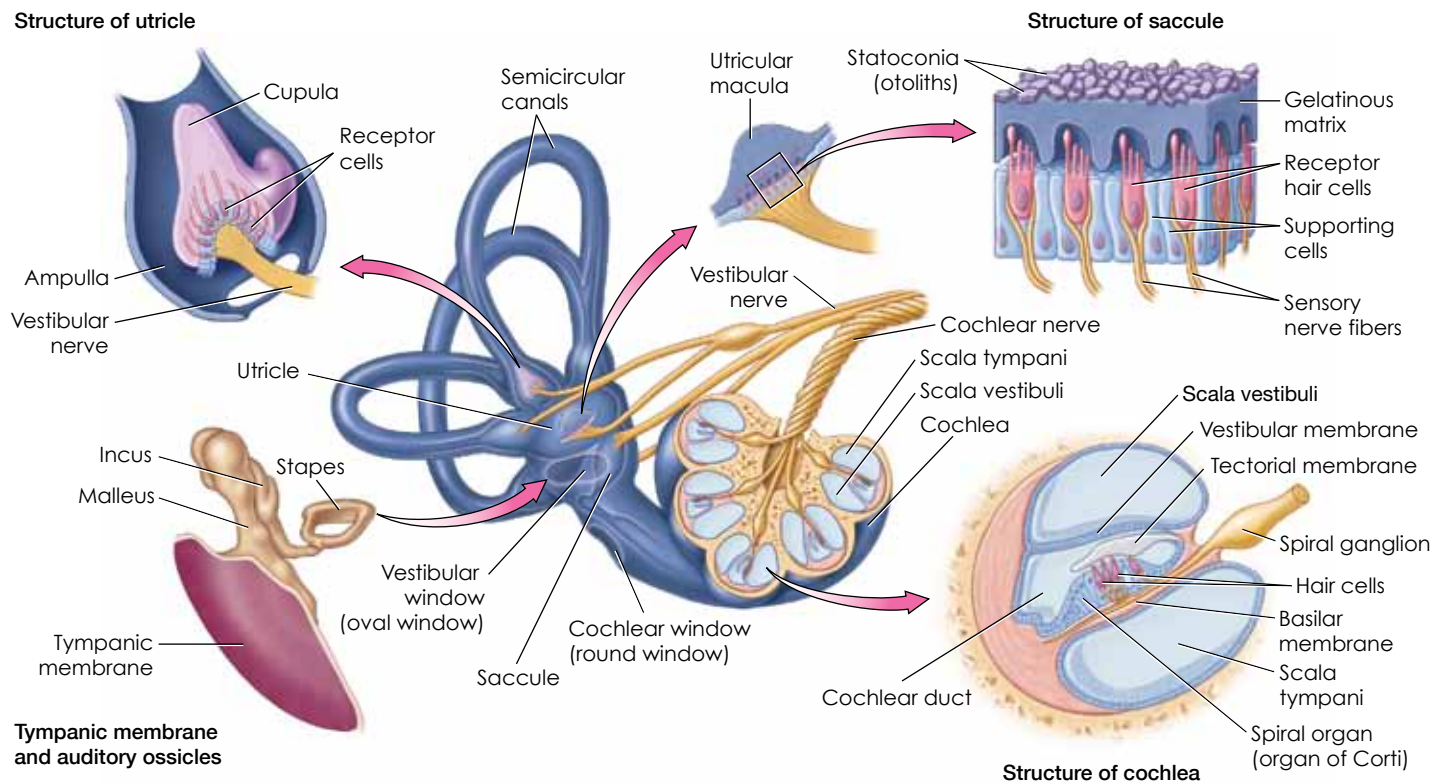
- |                     |                            |
|---------------------|----------------------------|
| 1. Helix            | 5. External auditory canal |
| 2. Triangular fossa | 6. Tragus                  |
| 3. Antihelix        | 7. Antitragus              |
| 4. Concha           | 8. Earlobe                 |



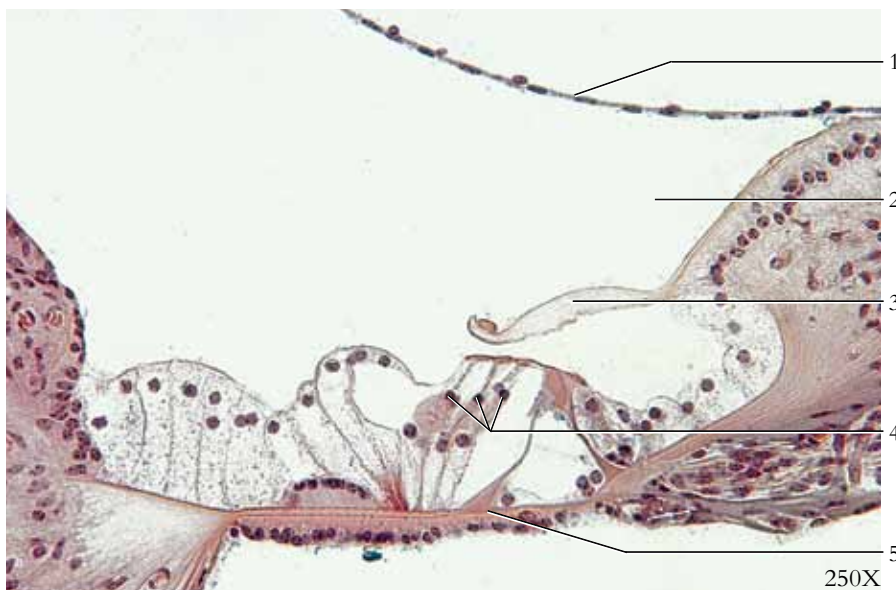
**Figure 11.8** Cochlea.

- |                        |                     |
|------------------------|---------------------|
| 1. Scala vestibuli     | 4. Basilar membrane |
| 2. Vestibular membrane | 5. Scala tympani    |
| 3. Cochlear duct       |                     |





**Figure 11.9** The structures of the middle ear and inner ear. The tympanic membrane and auditory ossicles (malleus, incus, stapes) are structures of the middle ear. The vestibular organs (utricle, saccule, semicircular canals) and cochlea (containing the spiral organ) are structures of the inner ear.



**Figure 11.10** Spiral organ (organ of Corti).

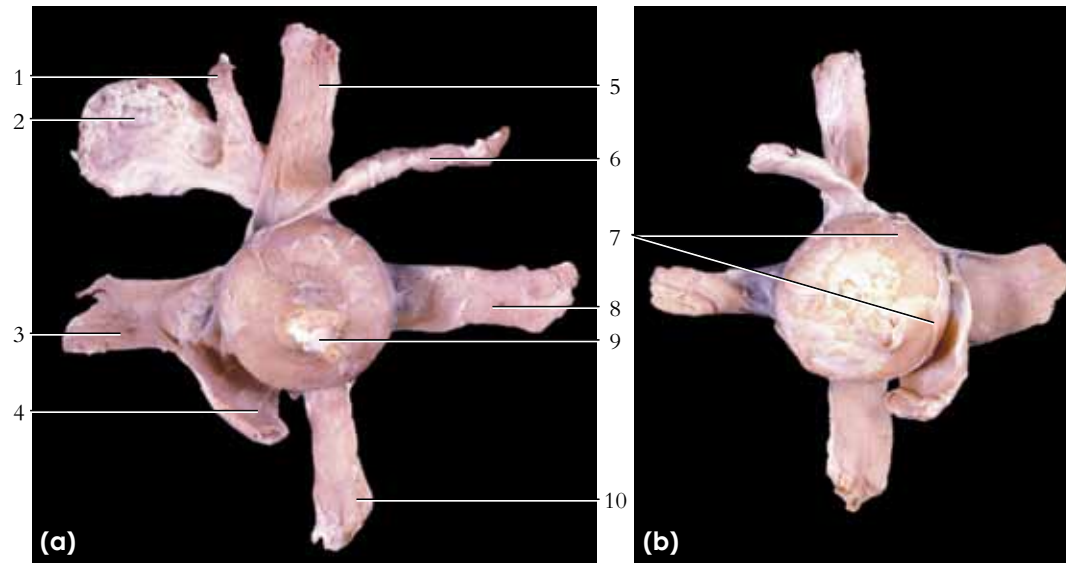
1. Vestibular membrane
2. Cochlear duct
3. Tectorial membrane
4. Hair cells
5. Basilar membrane



**Figure 11.11** Taste bud.

1. Epithelium of papilla
2. Taste buds
3. Tongue muscle

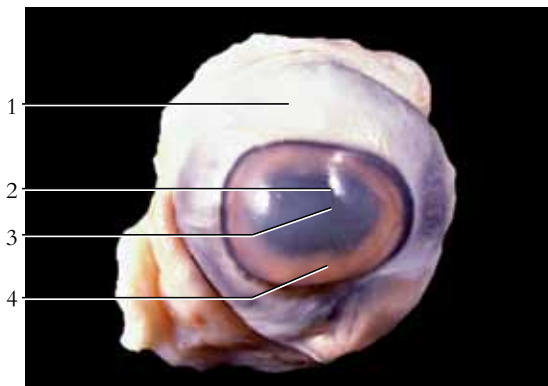




**Figure 11.12** Extrinsic eye muscles of a sheep. (a) A posterior view with the optic nerve intact.

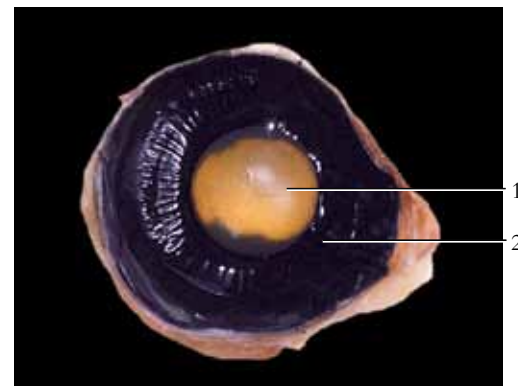
(b) A posterior view with the optic nerve removed.

- |                                    |                        |                        |
|------------------------------------|------------------------|------------------------|
| 1. Levator palpebrae superioris m. | 4. Inferior oblique m. | 8. Medial rectus m.    |
| 2. Lacrimal gland                  | 5. Superior rectus m.  | 9. Optic nerve         |
| 3. Lateral rectus m.               | 6. Superior oblique m. | 10. Inferior rectus m. |
|                                    | 7. Retractor bulbi     |                        |



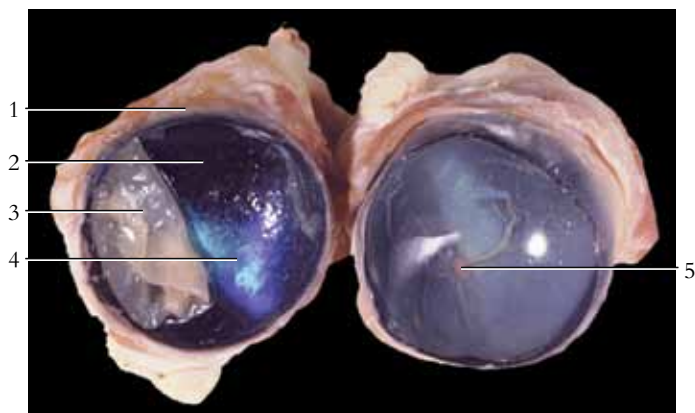
**Figure 11.13** A superficial view of the anterior eyeball of a sheep.

- |           |                         |
|-----------|-------------------------|
| 1. Sclera | 3. Pupil (dark opening) |
| 2. Cornea | 4. Iris                 |



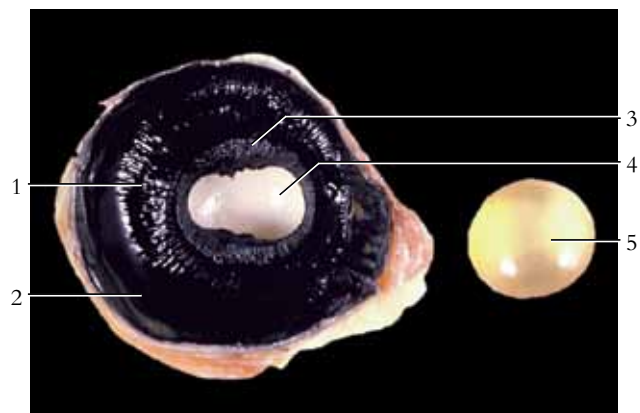
**Figure 11.14** An anterior view of the eyeball with the lens in natural position.

- |         |
|---------|
| 1. Lens |
| 2. Iris |



**Figure 11.15** Tunics of the sheep eyeball.

- |            |                    |
|------------|--------------------|
| 1. Sclera  | 4. Tapetum lucidum |
| 2. Choroid | 5. Optic disc      |
| 3. Retina  |                    |



**Figure 11.16** The internal anatomy of sheep eye.

- |                 |                   |
|-----------------|-------------------|
| 1. Ciliary body | 4. Pupil          |
| 2. Ora serrata  | 5. Lens (removed) |
| 3. Iris         |                   |

# Chapter 12

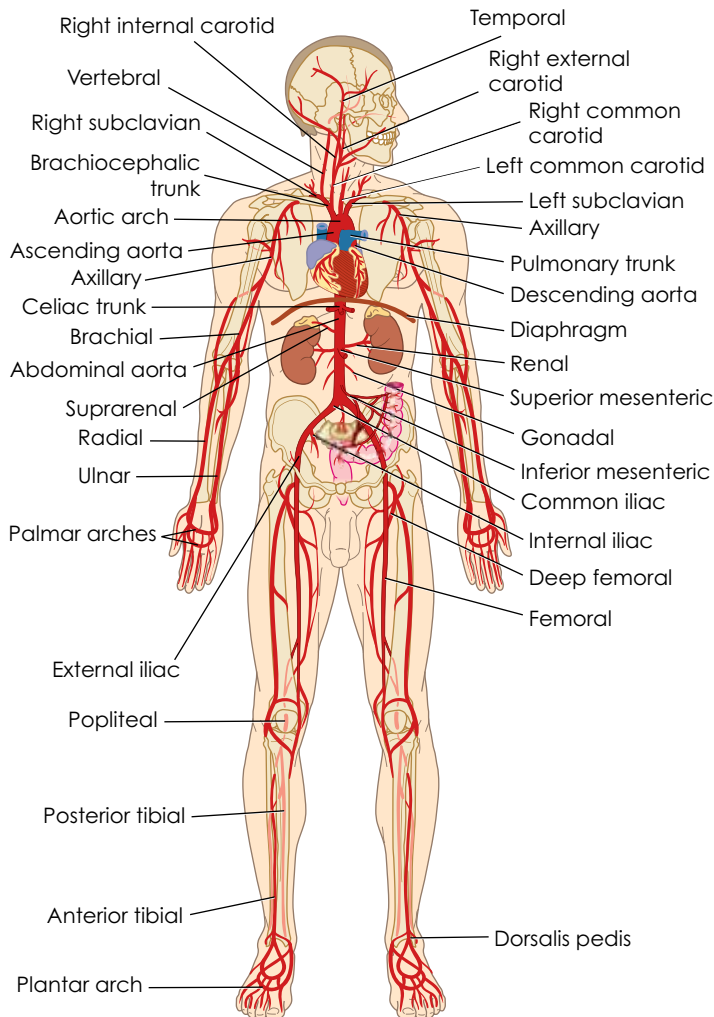
## Circulatory System

The circulatory system consists of the **blood, heart, and vessels**, each of which is essential to the life of a complex multicellular organism. Blood, a specialized connective tissue, consists of **formed elements** (erythrocytes, leukocytes, and thrombocytes) that are suspended and carried in the **plasma**. These formed elements function in transport, immunity, and blood-clotting mechanisms.

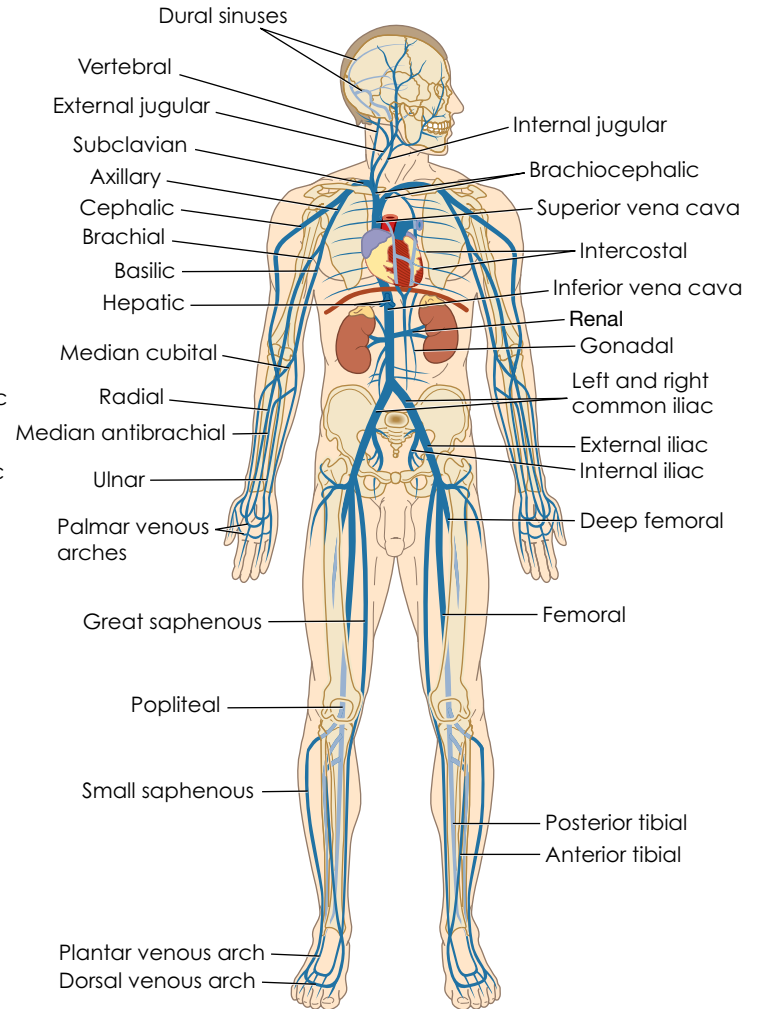
The heart is enclosed in a **pericardial sac** within the thoracic cavity. The wall of the heart consists of the **epicardium, myocardium, and endocardium**. The **right atrium** of the heart receives deoxygenated blood from the superior vena cava and inferior vena cava, and the **right ventricle** pumps deoxygenated blood into the **pulmonary trunk** to the **pulmonary arteries**. The **left atrium** receives oxygenated blood from the **pulmonary veins** and pumps oxygenated blood into the **left ventricle**. The left ventricle pumps blood into the **aorta**.

There are four heart valves that prohibit the backflow of blood: 1) The **right atrioventricular valve (tricuspid valve)** is located between the right atrium and the right ventricle; 2) the **pulmonary valve (pulmonary semilunar valve)** is located between the right ventricle and the pulmonary trunk; 3) the **left atrioventricular valve (bicuspid, or mitral valve)** is located between the left atrium and the left ventricle; and, 4) the **aortic valve (aortic semilunar valve)** is located between the left ventricle and the ascending aorta.

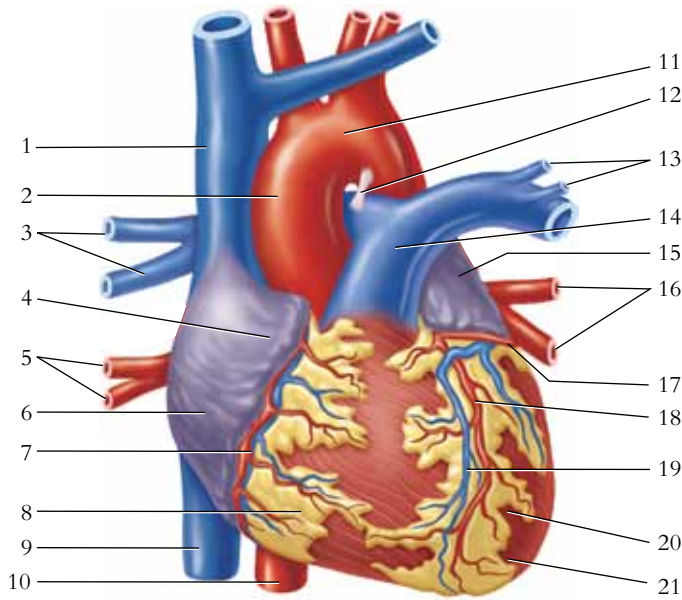
The **systemic arteries** arise from the aorta or branches of the aorta and transport blood away from the heart to smaller vessels called **arterioles**. From arterioles, the blood enters **capillaries** where diffusion with the surrounding cells may occur. Capillaries converge forming **venules**, which in turn converge forming larger vessels called **veins**. Veins are vessels that transport blood toward the heart.



**Figure 12.1** The principal arteries of the body.

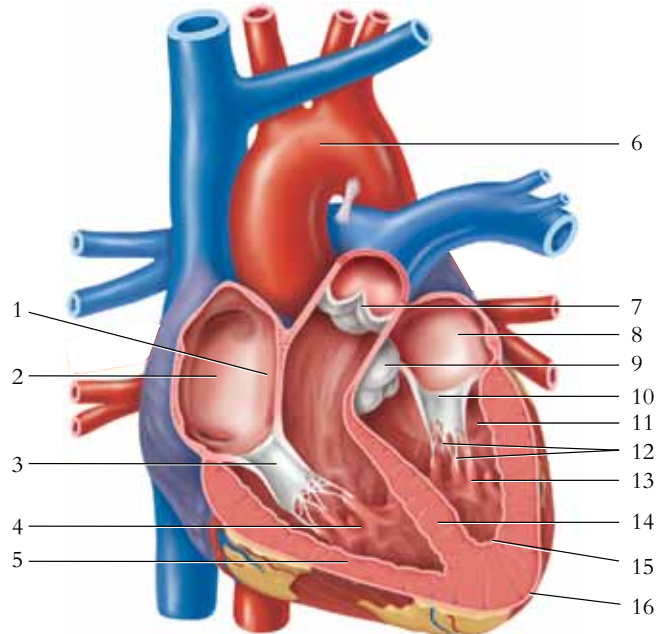


**Figure 12.2** The principal veins of the body.



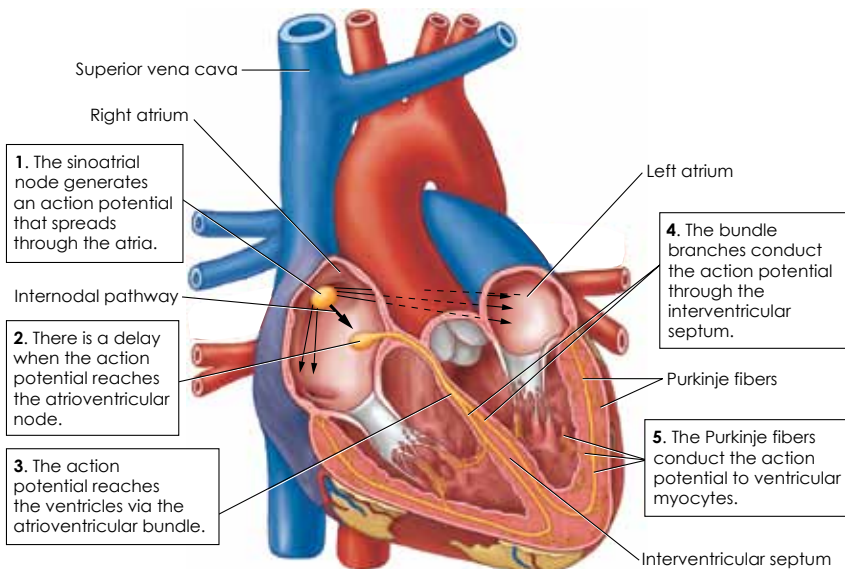
**Figure 12.3** An anterior view of the structure of the heart.

- |                                       |                                       |
|---------------------------------------|---------------------------------------|
| 1. Superior vena cava                 | 12. Ligamentum arteriosum             |
| 2. Ascending aorta                    | 13. Branches of left pulmonary artery |
| 3. Branches of right pulmonary artery | 14. Pulmonary trunk                   |
| 4. Auricle of right atrium            | 15. Left atrium                       |
| 5. Right pulmonary veins              | 16. Left pulmonary veins              |
| 6. Right atrium                       | 17. Circumflex artery                 |
| 7. Right coronary artery and vein     | 18. Anterior interventricular artery  |
| 8. Right ventricle                    | 19. Anterior interventricular vein    |
| 9. Inferior vena cava                 | 20. Left ventricle                    |
| 10. Thoracic aorta                    | 21. Apex of heart                     |
| 11. Aortic arch                       |                                       |

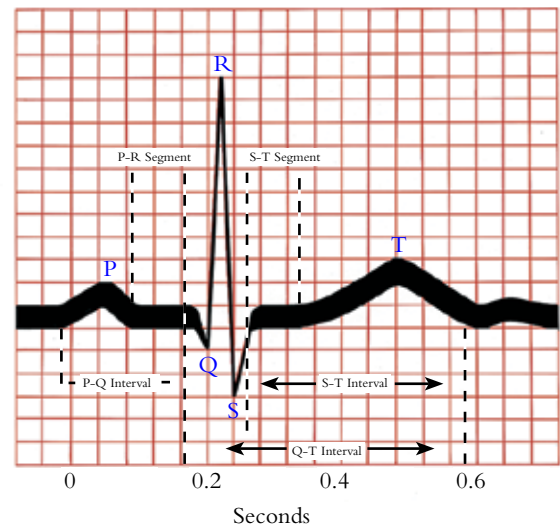


**Figure 12.4** An internal view of the structure of the heart.

- |                       |                             |
|-----------------------|-----------------------------|
| 1. Interatrial septum | 9. Aortic valve             |
| 2. Right atrium       | 10. Bicuspid valve          |
| 3. Tricuspid valve    | 11. Left ventricle          |
| 4. Right ventricle    | 12. Chordae tendinae        |
| 5. Myocardium         | 13. Papillary muscle        |
| 6. Aortic arch        | 14. Interventricular septum |
| 7. Pulmonary valve    | 15. Endocardium             |
| 8. Left atrium        | 16. Visceral pericardium    |

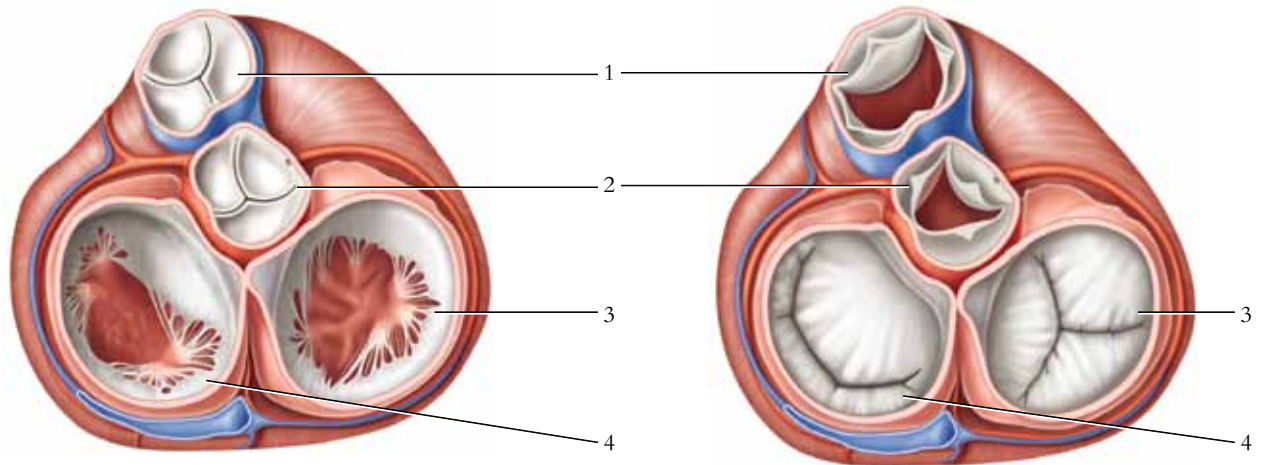


**Figure 12.5** The conduction system of the heart.



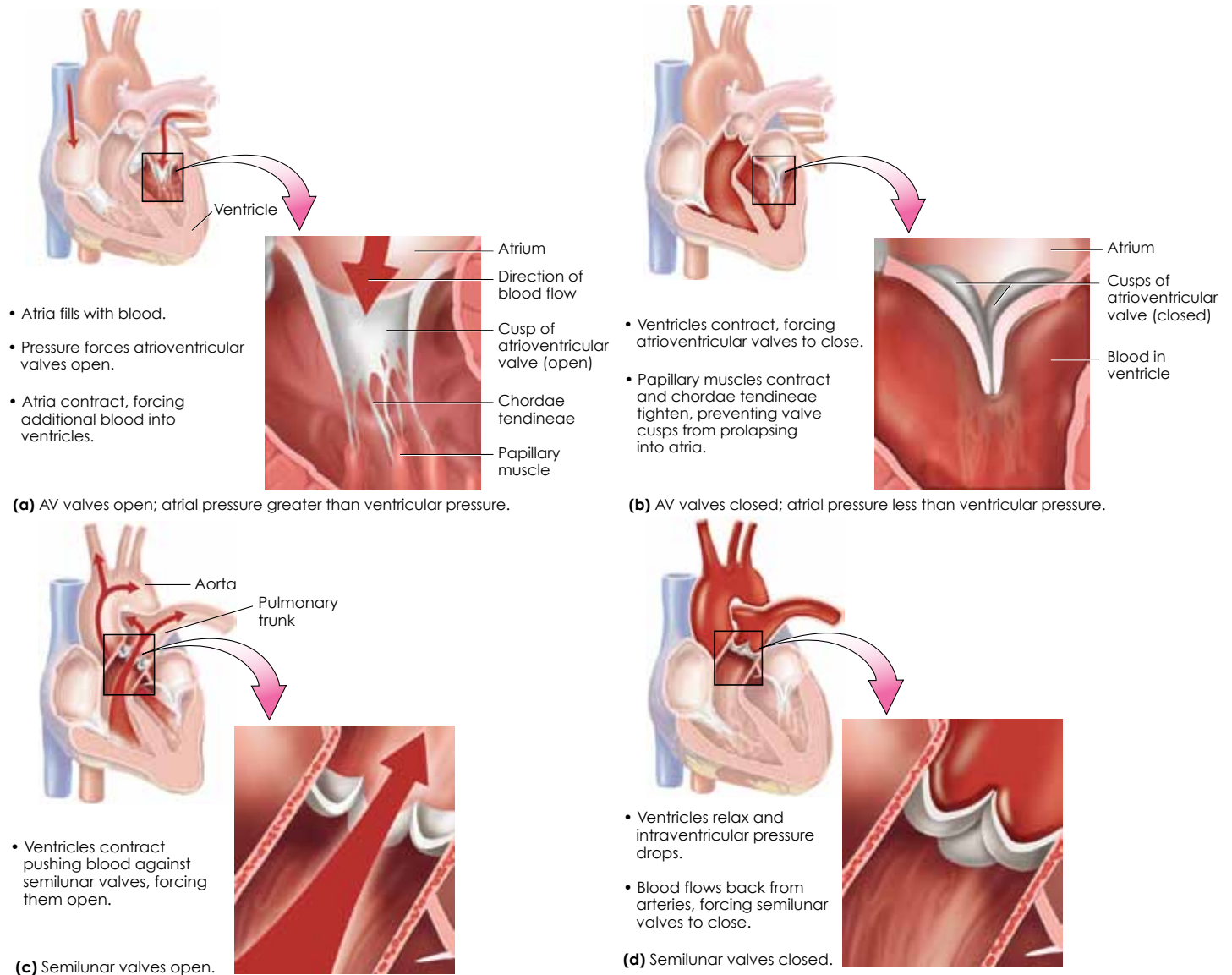
**Figure 12.6** A normal electrocardiogram (ECG).





**Figure 12.7** The valves of the heart. (a) Diastole, atrioventricular valves open. (b) Systole, semilunar valves open.

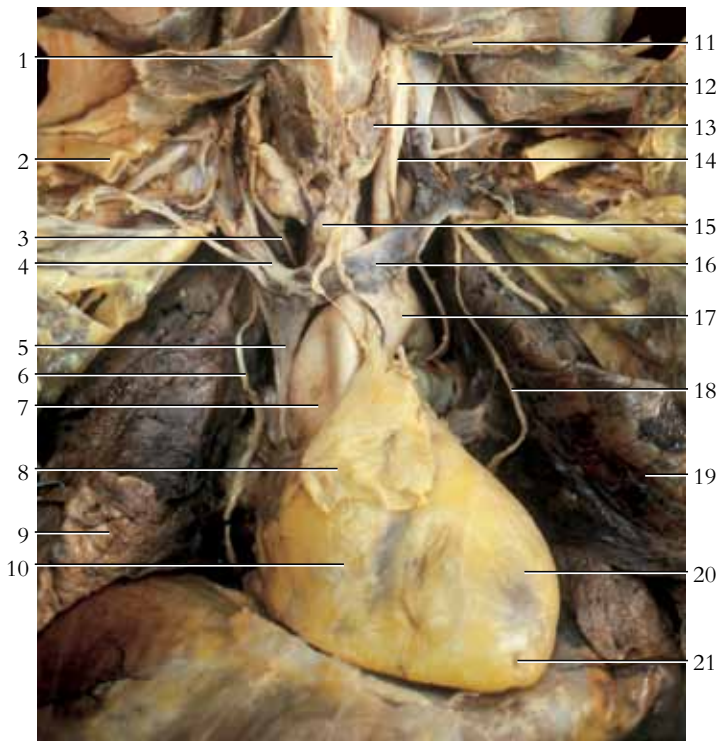
- |                              |   |
|------------------------------|---|
| 1. Pulmonary semilunar valve | 3. Tricuspid (right atrioventricular) valve |
| 2. Aortic semilunar valve    | 4. Bicuspid (left atrioventricular) valve   |



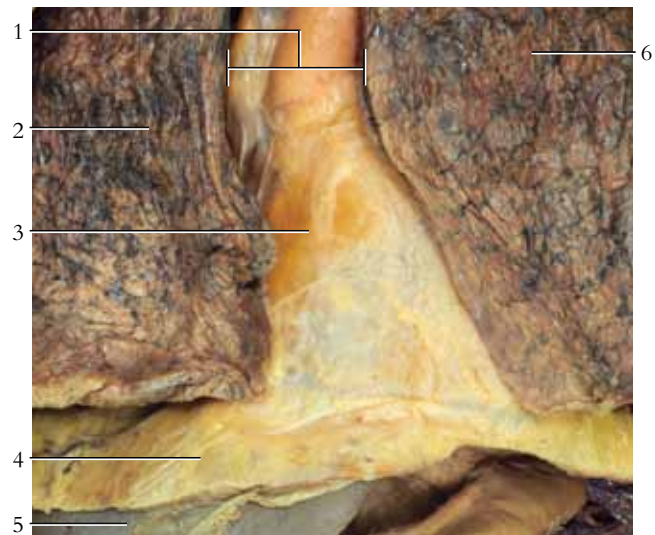
**Figure 12.8** Cardiac cycle.

**Table 12.1** Valves of the heart.

| Valve  | Location                                 | Structure and Function  |
|--|--|---|
| <b>Right atrioventricular valve</b><br>(tricuspid valve)               | Between right atrium and right ventricle | Consists of three cusps that prevent backflow of blood into right atrium during systole (ventricular contraction)                       |
| <b>Pulmonary valve</b><br>(pulmonary semilunar valve)                  | Entrance to pulmonary trunk              | Consists of three partial moon-shaped cups that prevent backflow of blood into right ventricle during diastole (ventricular relaxation) |
| <b>Left atrioventricular valve</b><br>(bicuspid valve or mitral valve) | Between left atrium and left ventricle   | Consists of two cusps that prevent backflow of blood into left atrium during systole  |
| <b>Aortic valve</b><br>(aortic semilunar valve)                        | Entrance to ascending aorta              | Consists of three partial-moon-shaped cups that prevent backflow of blood into left ventricle during diastole                           |


**Figure 12.9** An anterior view of the heart and associated structures.

1. Thyroid cartilage of larynx
2. First rib (cut)
3. Right vagus nerve
4. Right brachiocephalic vein
5. Superior vena cava
6. Right phrenic nerve
7. Ascending aorta
8. Pericardium (cut)
9. Right lung
10. Right ventricle of heart
11. Sternohyoid (cut and reflected)
12. Left common carotid artery
13. Thyroid gland (cut)
14. Left vagus nerve
15. Brachiocephalic artery
16. Left brachiocephalic vein
17. Aortic arch
18. Left phrenic nerve
19. Left lung
20. Left ventricle of heart
21. Apex of heart

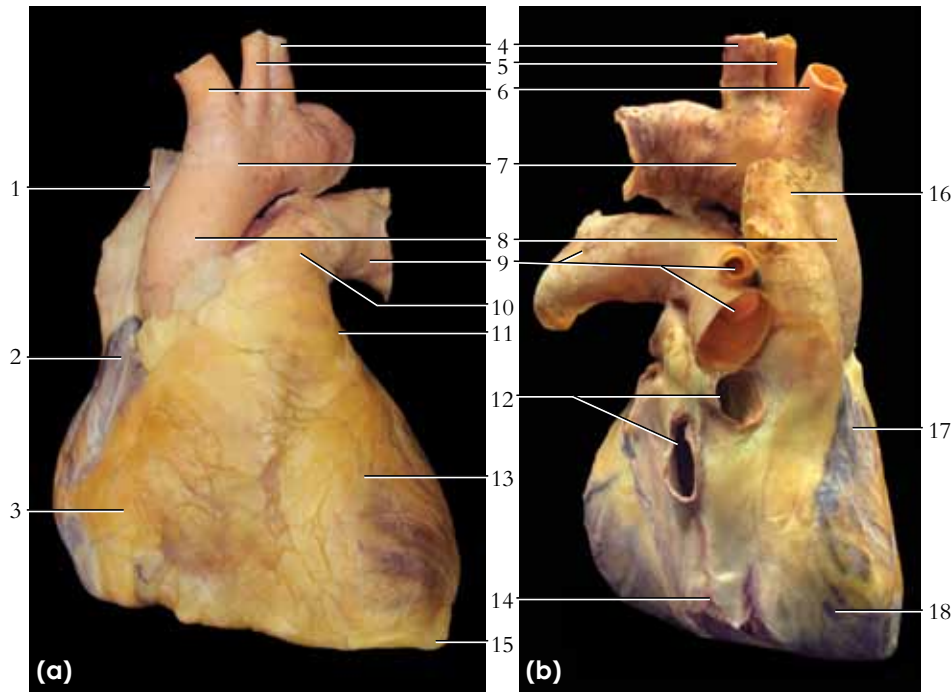

**Figure 12.10** The position of the heart within the pericardium.

1. Mediastinum
2. Right lung
3. Pericardium
4. Diaphragm
5. Liver
6. Left lung


**Figure 12.11** Wall of the heart.

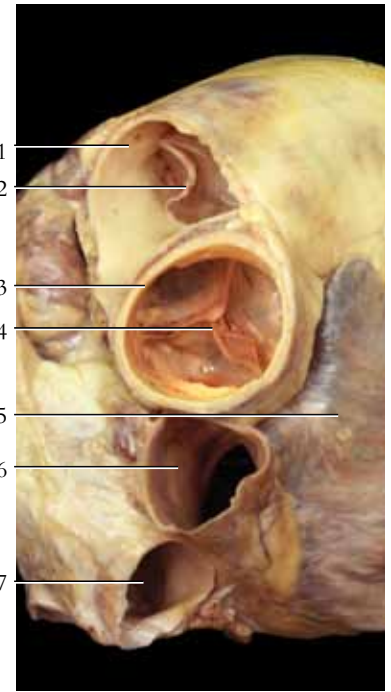
1. Epicardium
2. Myocardium
3. Endocardium





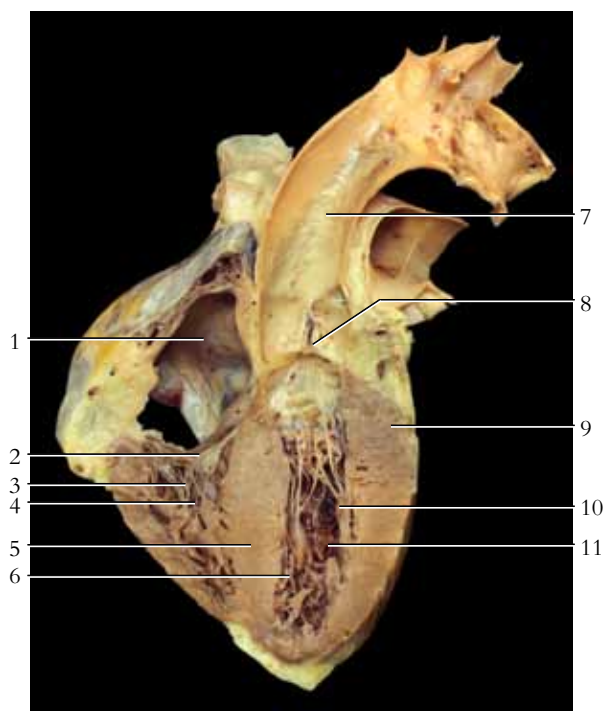
**Figure 12.12** An anterior (a) and posterior (b) views of the heart and great vessels.

1. Superior vena cava
2. Right atrium
3. Right ventricle
4. Left subclavian artery
5. Left common carotid artery
6. Brachiocephalic trunk
7. Aortic arch
8. Ascending aorta
9. Pulmonary arteries
10. Pulmonary trunk
11. Left atrium
12. Pulmonary veins
13. Left ventricle
14. Inferior vena cava
15. Apex of heart
16. Superior vena cava
17. Right atrium
18. Right ventricle



**Figure 12.13** A superior view of the great vessels of the heart and aortic valve.

1. Pulmonary trunk
2. Pulmonary valve
3. Ascending aorta
4. Aortic valve
5. Right atrium
6. Superior vena cava
7. Pulmonary vein

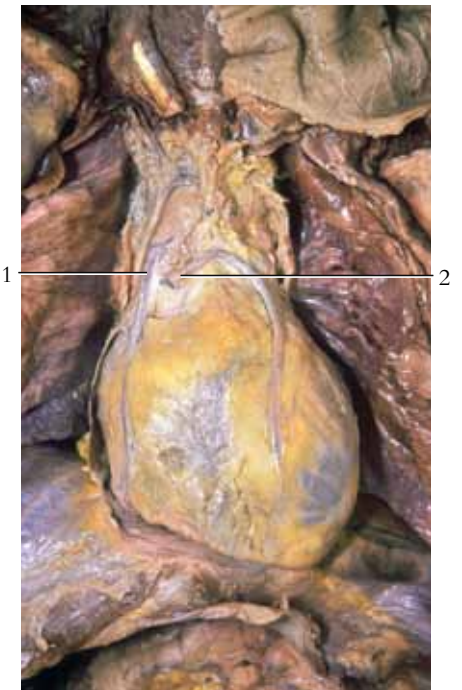


**Figure 12.14** The internal structure of the heart.

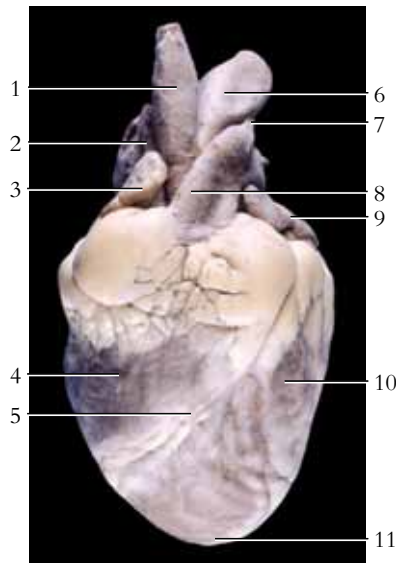
1. Right atrium
2. Right atrioventricular valve
3. Chordae tendinae
4. Right ventricle
5. Interventricular septum
6. Trabeculae carneae
7. Ascending aorta
8. Aortic valve
9. Myocardium
10. Papillary muscle
11. Left ventricle

**Figure 12.15** A double coronary artery bypass surgery. Several vessels may be used in the autotransplant, including the internal thoracic artery and the great saphenous vein.

1. A graft to the ascending aorta
2. A graft to the left coronary artery

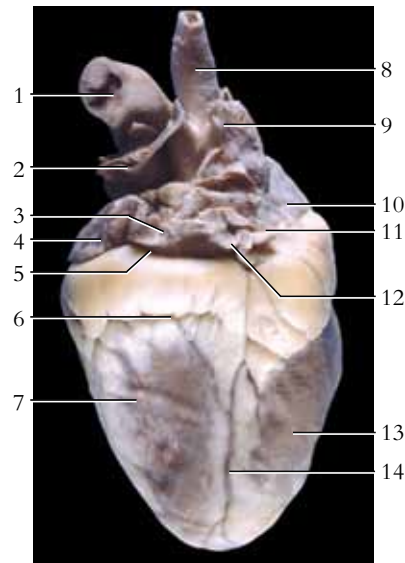






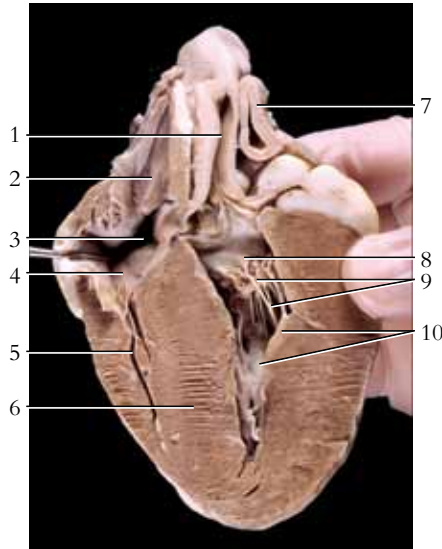
**Figure 12.16** A ventral view of mammalian (sheep) heart.

- |                                  |                                |
|----------------------------------|--------------------------------|
| 1. Brachiocephalic artery        | 6. Aortic arch                 |
| 2. Cranial vena cava             | 7. Ligamentum arteriosum       |
| 3. Right auricle of right atrium | 8. Pulmonary trunk             |
| 4. Right ventricle               | 9. Left auricle of left atrium |
| 5. Interventricular groove       | 10. Left ventricle             |
|                                  | 11. Apex of heart              |



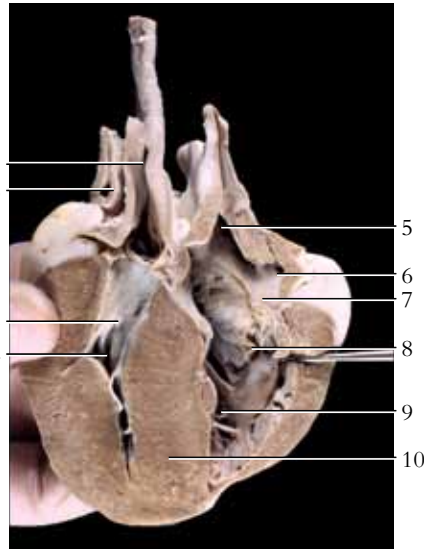
**Figure 12.17** A dorsal view of mammalian (sheep) heart.

- |                            |                             |
|----------------------------|-----------------------------|
| 1. Aorta                   | 8. Brachiocephalic artery   |
| 2. Pulmonary artery        | 9. Cranial vena cava        |
| 3. Pulmonary vein          | 10. Right auricle           |
| 4. Left auricle            | 11. Right atrium            |
| 5. Left atrium             | 12. Pulmonary vein          |
| 6. Atrioventricular groove | 13. Right ventricle         |
| 7. Left ventricle          | 14. Interventricular groove |



**Figure 12.18** A coronal section of the mammalian (sheep) heart .

1. Aorta
2. Cranial vena cava
3. Right atrium
4. Right atrioventricular (tricuspid) valve
5. Right ventricle
6. Interventricular septum
7. Pulmonary artery
8. Left atrioventricular (bicuspid) valve
9. Chordae tendineae
10. Papillary muscles



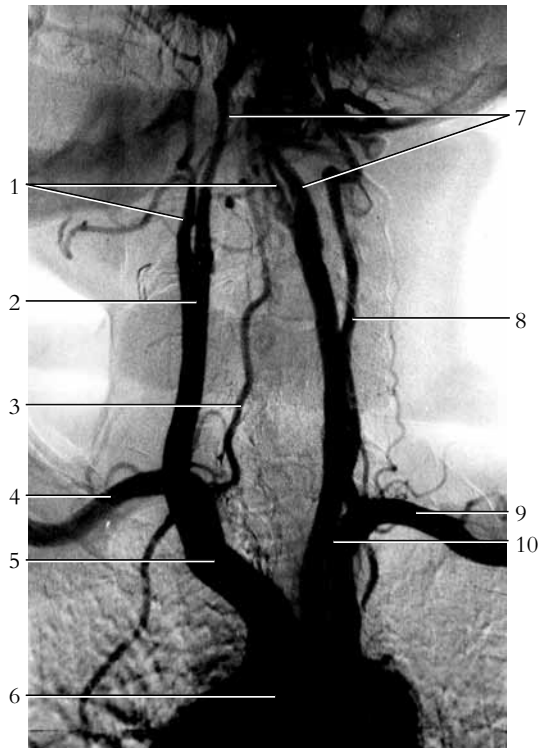
**Figure 12.19** A coronal section of the mammalian (sheep) heart showing the valves.

1. Opening of the brachiocephalic artery
2. Pulmonary artery
3. Left atrioventricular (bicuspid) valve
4. Left ventricle
5. Opening of cranial vena cava
6. Opening of coronary sinus
7. Right atrium
8. Right atrioventricular (tricuspid) valve
9. Right ventricle
10. Interventricular septum



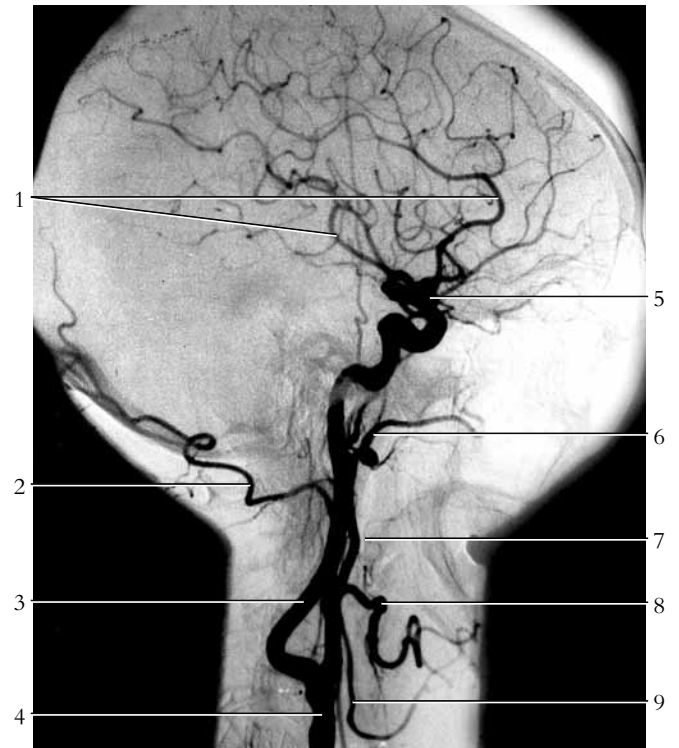
**Figure 12.20** A coronal section of the mammalian (sheep) heart showing openings of coronary arteries.

1. Opening of brachiocephalic artery
2. Opening of left coronary artery
3. Opening of right coronary artery
4. Aortic valve
5. Coronary vessel



**Figure 12.21** An angiogram showing the aortic arch and its branches.

- |                                |                                |
|--------------------------------|--------------------------------|
| 1. External carotid arteries   | 6. Aortic arch                 |
| 2. Right common carotid artery | 7. Internal carotid arteries   |
| 3. Right vertebral artery      | 8. Left vertebral artery       |
| 4. Right subclavian artery     | 9. Left subclavian artery      |
| 5. Brachiocephalic trunk       | 10. Left common carotid artery |



**Figure 12.22** An angiogram showing the branches of the common carotid and external carotid arteries.

- |   |                            |
|---|----------------------------|
| 1. Meningeal arteries   | 6. Maxillary artery        |
| 2. Occipital artery   | 7. External carotid artery |
| 3. Internal carotid artery  | 8. Facial artery           |
| 4. Common carotid artery  | 9. Superior thyroid artery |
| 5. Internal carotid artery to cerebral arterial circle (circle of Willis) |                            |

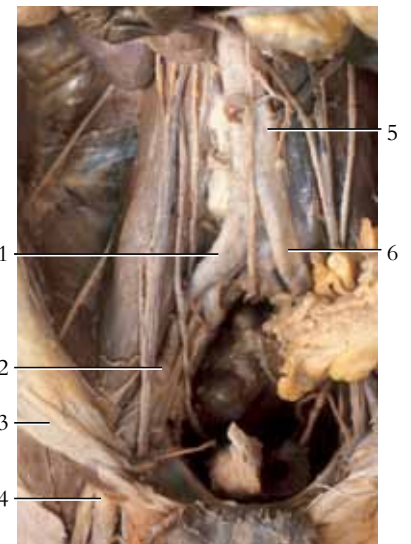


**Figure 12.23** The surface anatomy identifying the superficial vessels of the forearm.

- |  |
|--|
| 1. Cubital fossa                           |
| 2. Cephalic vein                           |
| 3. Radial artery (arterial pressure point) |
| 4. Basilic vein                            |
| 5. Median cubital vein                     |
| 6. Median antebrachial vein                |
| 7. Tendon of palmaris longus m.            |

**Figure 12.24** The arteries of the lower abdominal cavity.

- |                              |
|------------------------------|
| 1. Inferior vena cava        |
| 2. Abdominal aorta           |
| 3. Right common iliac artery |
| 4. Adrenal gland             |
| 5. Left renal artery         |
| 6. Left renal vein           |
| 7. Left kidney               |
| 8. Ureter                    |
| 9. Left gonadal vein         |



**Figure 12.25** The arteries of the pelvic cavity.

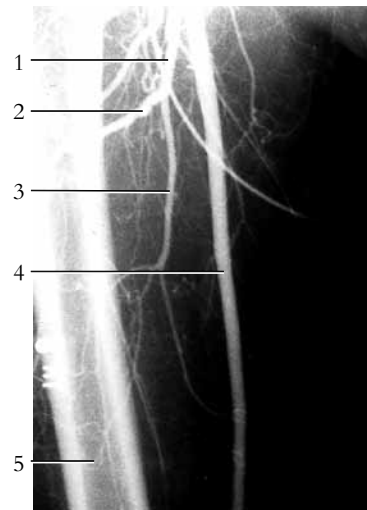
- |                              |
|------------------------------|
| 1. Right common iliac artery |
| 2. External iliac artery     |
| 3. Inguinal ligament         |
| 4. Femoral artery            |
| 5. Abdominal aorta           |
| 6. Left common iliac artery  |





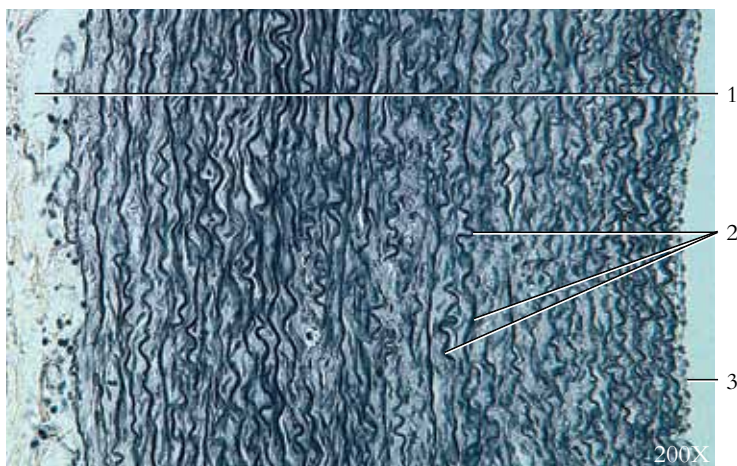
**Figure 12.26** An angiogram of the common iliac arteries and their branches.

1. Common iliac artery
2. External iliac artery
3. Femoral artery
4. Deep femoral artery
5. Lumbar vertebra
6. Internal iliac artery
7. Gluteal arteries
8. Obturator artery
9. Symphysis pubis
10. Lateral circumflex femoral artery



**Figure 12.27** An angiogram of the arteries of the right thigh.

1. Deep femoral artery
2. Lateral circumflex femoral artery
3. Medial femoral circumflex artery
4. Femoral artery
5. Femur

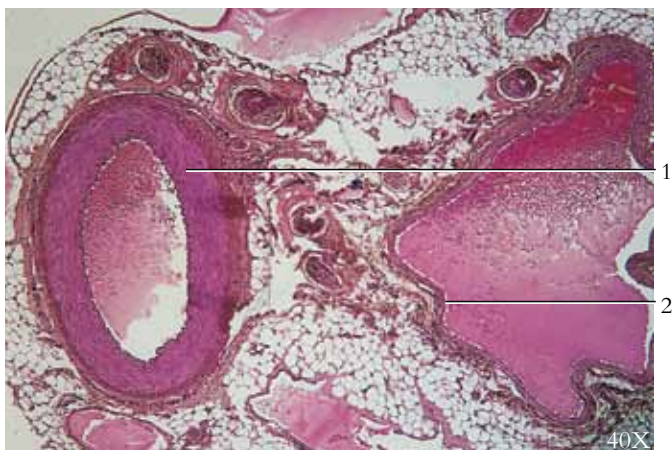


**Figure 12.28** Wall of elastic artery.

1. Tunica adventitia
2. Elastic laminae (in tunica media)
3. Tunica intima

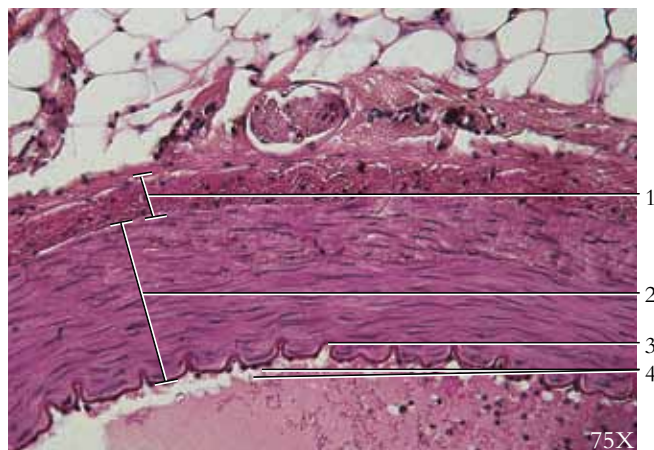


**Figure 12.29** Arterial plaque from femoral arteries.



**Figure 12.30** Artery and vein.

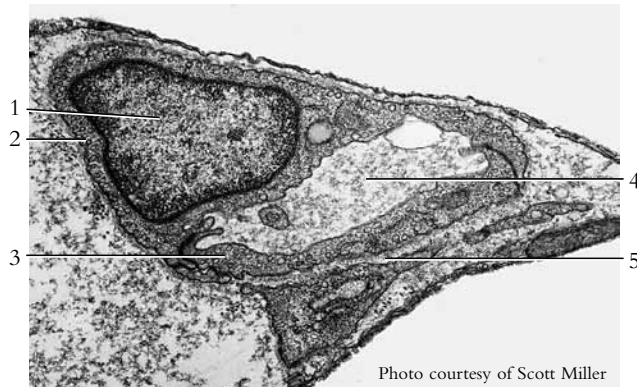
1. Artery
2. Vein



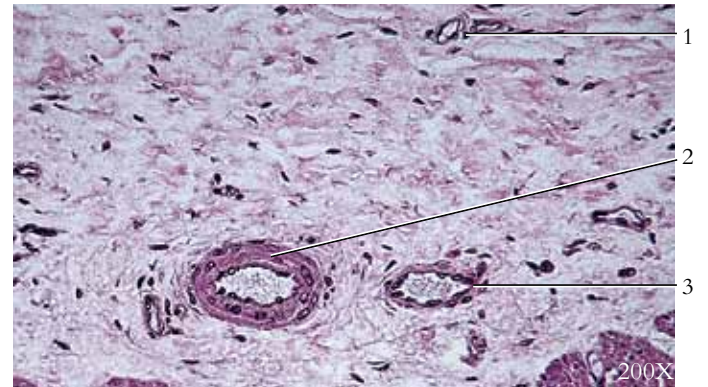
**Figure 12.31** Wall of muscular artery.

1. Tunica adventitia
2. Tunica media
3. Internal elastic membrane
4. Endothelial cells

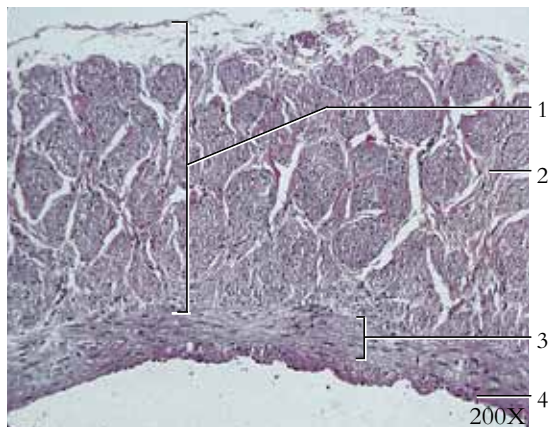




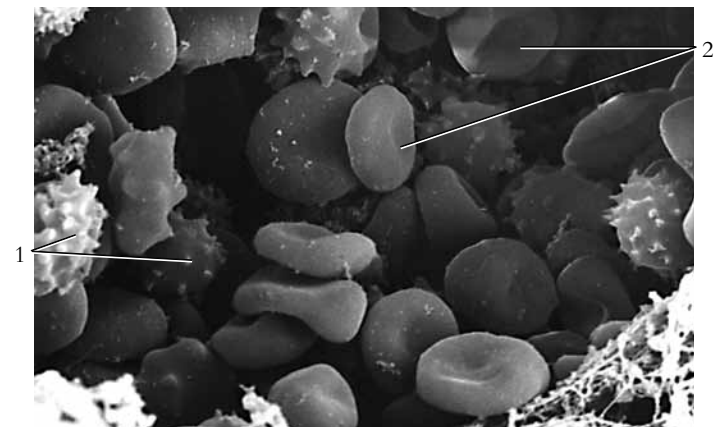
**Figure 12.32** SEM photomicrograph of a capillary.  
 1. Nucleus  
 2. Endocytic vesicles  
 3. Endothelial cell  
 4. Lumen of capillary  
 5. Basal lamina



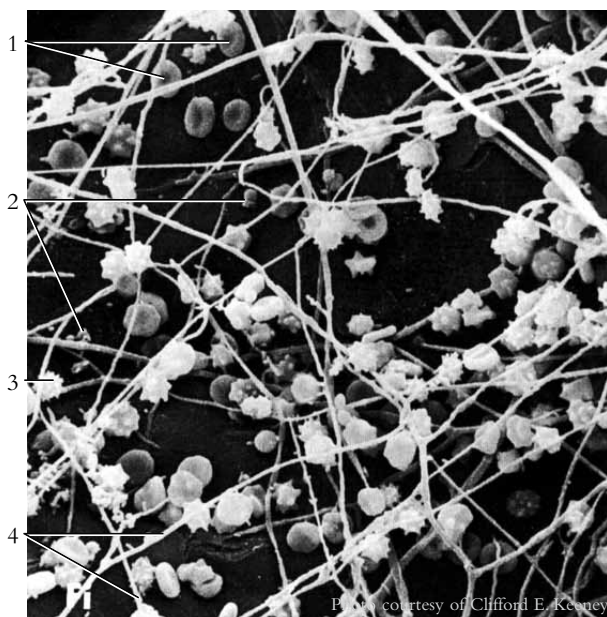
**Figure 12.33** Arteriole, capillary, and venule.  
 1. Capillary  
 2. Arteriole  
 3. Venule



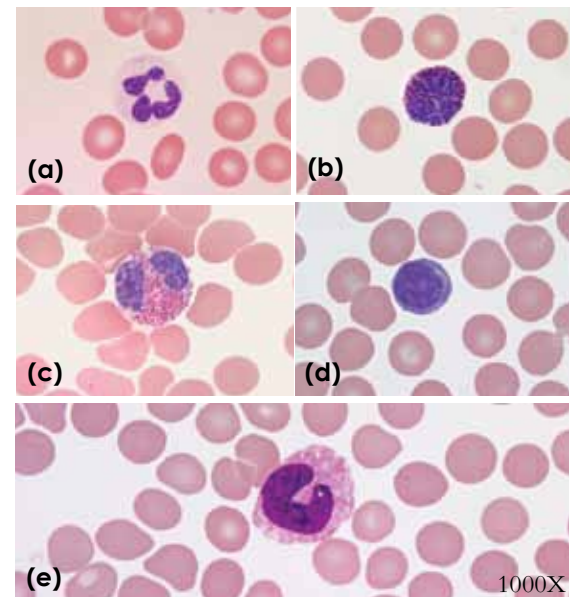
**Figure 12.34** Wall of large vein.  
 1. Tunica adventitia  
 2. Longitudinally oriented smooth muscle  
 3. Tunica media  
 4. Tunica intima



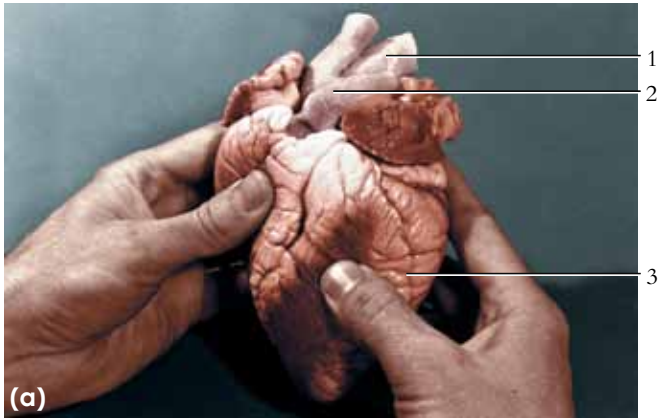
**Figure 12.35** An electron micrograph of blood cells in the lumen of a blood vessel.  
 1. Leukocytes  
 2. Erythrocytes



**Figure 12.36** An electron micrograph of a blood clot.  
 1. Erythrocytes  
 2. Thrombocytes  
 3. Leukocyte  
 4. Fibrin strand

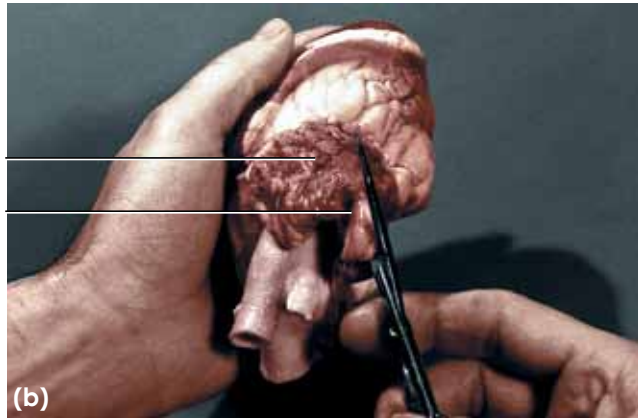


**Figure 12.37** Types of leukocytes.  
 (a) Neutrophil  
 (b) Basophil  
 (c) Eosinophil  
 (d) Lymphocyte  
 (e) Monocyte



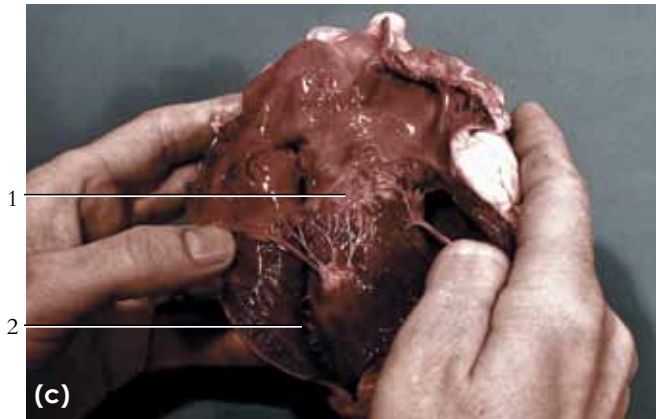
Position the heart so the ventral surface faces you. Notice the thicker ventricular walls, especially the left ventricle.

1. Aortic arch
2. Pulmonary trunk
3. Left ventricle



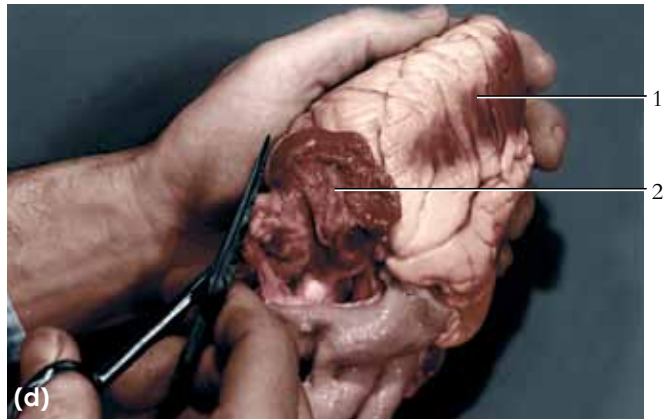
Insert the scissors into the superior vena cava. The cut should expose the interior of the right atrium. Notice the right atrioventricular (tricuspid) valve.

1. Right atrium
2. Superior vena cava



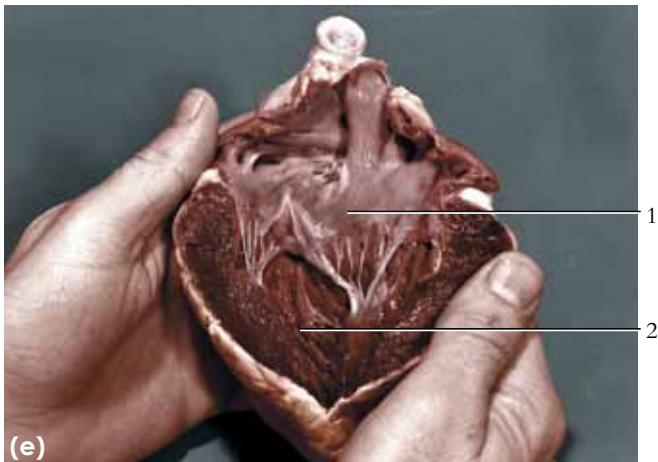
Continue the incision through the right ventricle to the apex of the heart. Observe the structure of the valve.

1. Right atrioventricular valve
2. Right ventricle



Begin the next incision in the left atrium. This time, continue through both the atrium and the ventricle.

1. Left ventricle
2. Left atrium



Expose the left ventricle and atrium. Notice the difference between the right and left ventricles, especially the thicker muscular wall of the left ventricle.

1. Left atrioventricular (bicuspid) valve
2. Left ventricle

**Figure 12.38** The steps of a sheep heart dissection (a-e).

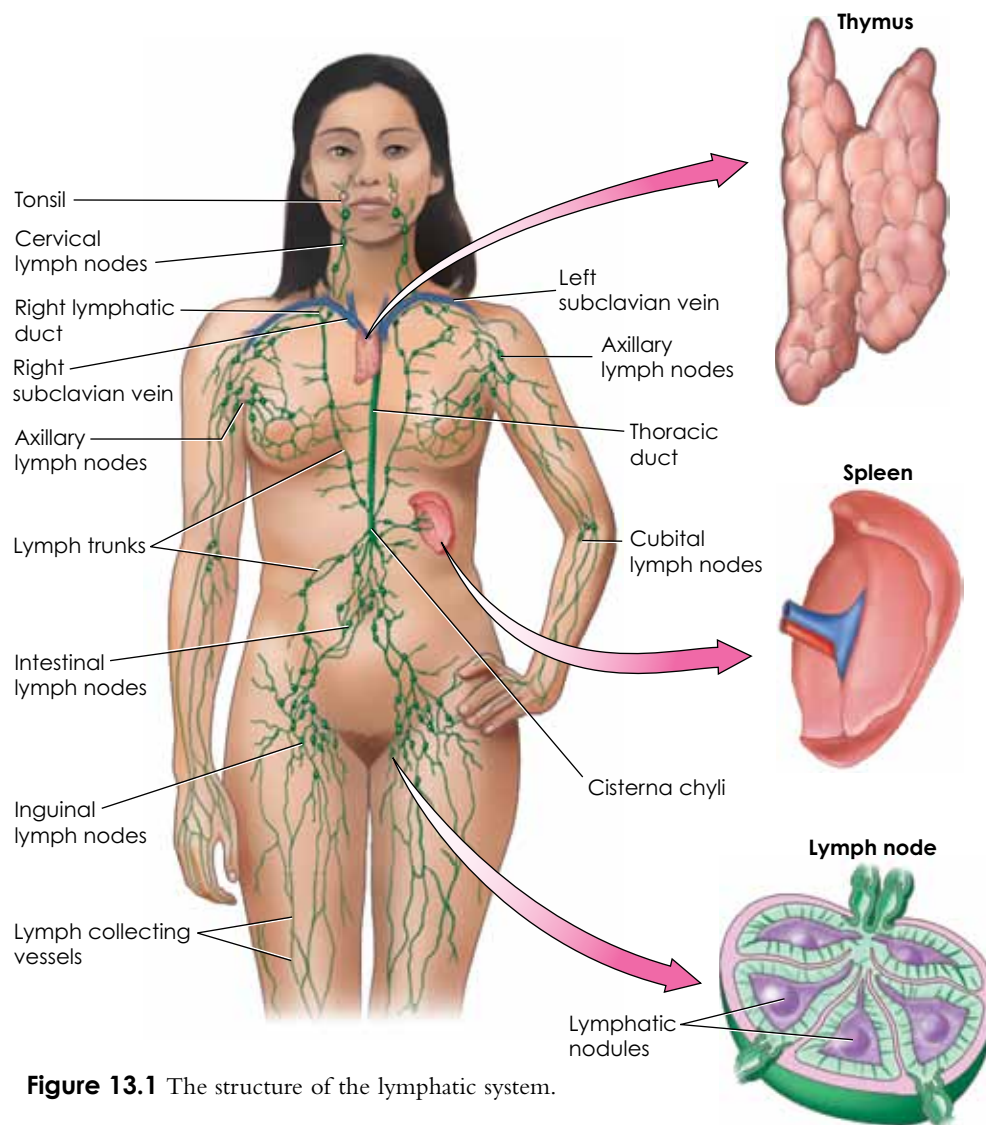


# Chapter 13

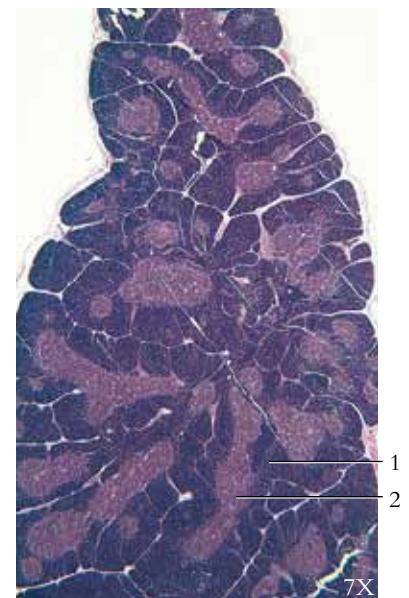
## Lymphatic System

The lymphatic system is closely interrelated to the circulatory system. The functions of the lymphatic system are basically fourfold: 1) it transports excess interstitial (tissue) fluid, which was initially formed as a blood filtrate, back to the bloodstream; 2) it maintains homeostasis around body cells by providing a constantly moist intercellular environment, which assists movements of materials into and out of cells; 3) it serves as the route by which absorbed fat from the small intestine is transported to the blood; and 4) it helps provide immunological defenses against disease-causing agents.

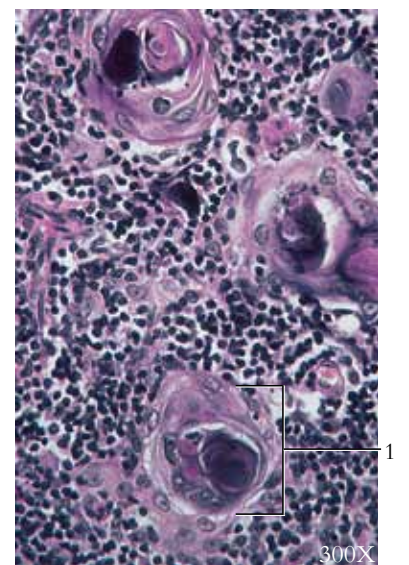
**Lymph capillaries** drain tissue fluid, which is formed from blood plasma; when this fluid enters lymph capillaries, it is called **lymph**. Lymph is returned to the venous system via two large lymph ducts—the **thoracic duct** and the **right lymphatic duct** (fig. 13.1). On the way to these drainage ducts, lymph filters through **lymph nodes**, which contain phagocytic cells and germinal centers that produce lymphocytes. The **spleen** and **thymus** are considered lymphoid organs because they also produce lymphocytes.



**Figure 13.1** The structure of the lymphatic system.

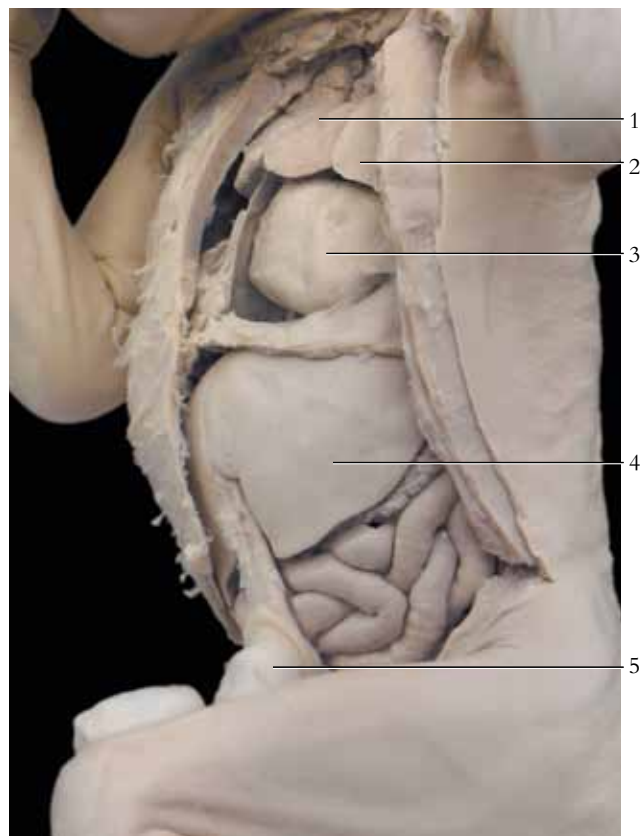


**Figure 13.2** Thymus.  
1. Cortex 2. Medulla



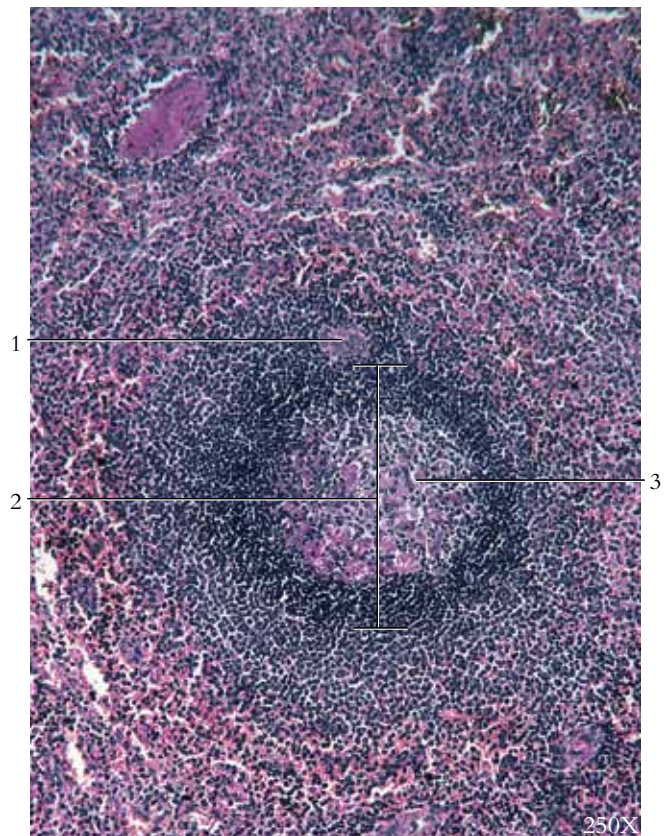
**Figure 13.3** Thymic medulla.  
1. Hassall's corpuscle





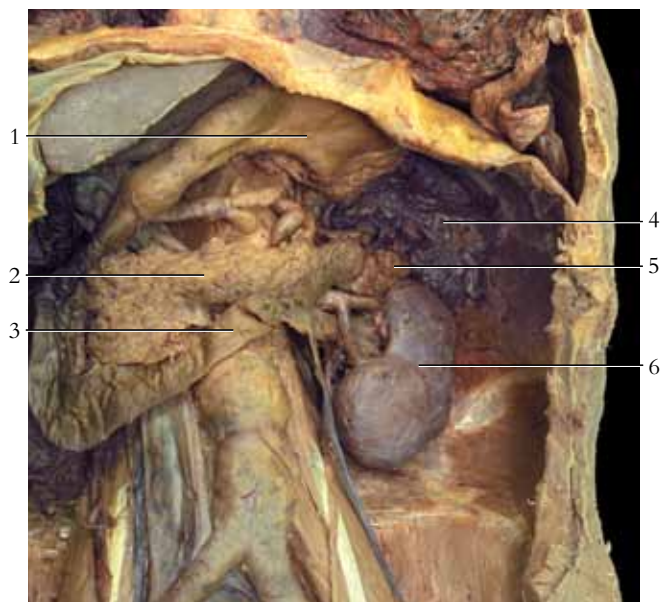
**Figure 13.4** The thymus within a fetus, during the third trimester of development.

1. Thymus
2. Lung
3. Heart
4. Liver
5. Umbilical cord



**Figure 13.5** Spleen.

1. Central artery
2. Splenic nodule
3. Germinal center



**Figure 13.6** The spleen within the abdominal cavity with overlying viscera removed.

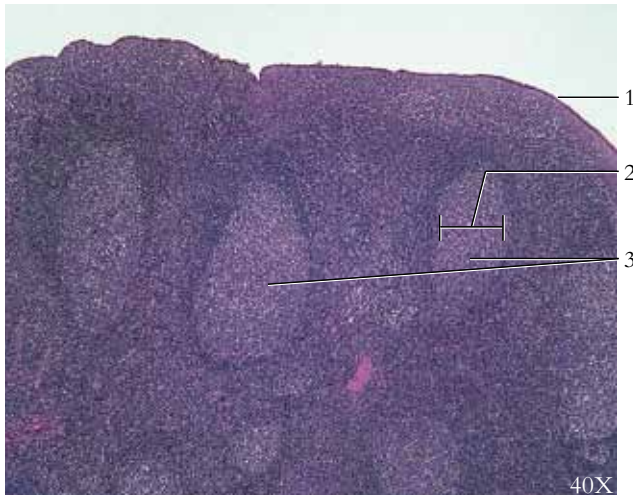
1. Stomach (reflected)
2. Pancreas
3. Duodenum
4. Spleen
5. Adrenal gland
6. Kidney



**Figure 13.7** The spleen and pancreas.

1. Pancreas
2. Pancreatic duct
3. Spleen
4. Splenic artery
5. Splenic vein





**Figure 13.8** Palatine tonsil.

1. Oral mucosa
2. Lymphatic nodule
3. Germinal centers

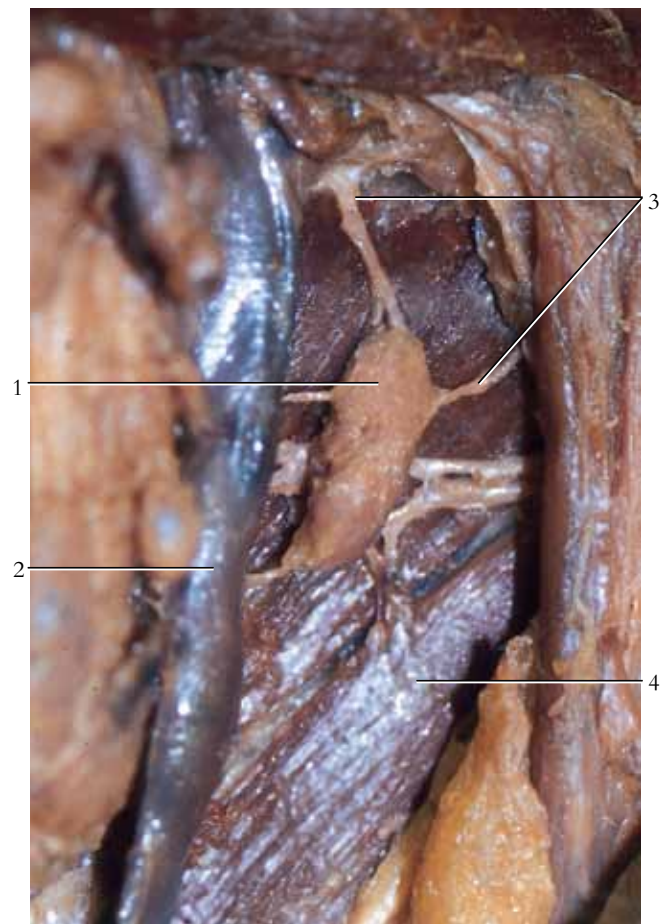


**Figure 13.9** Palatine tonsils that have been removed in a tonsillectomy. Chronic tonsillitis generally requires a tonsillectomy.



**Figure 13.10** Lymph node.

1. Medulla of lymph node
2. Capsule
3. Lymphatic nodule
4. Cortex of lymph node



**Figure 13.11** A lymph node.

1. Lymph node
2. Vein
3. Lymphatic vessels
4. Muscle



# Chapter 14

## Respiratory System

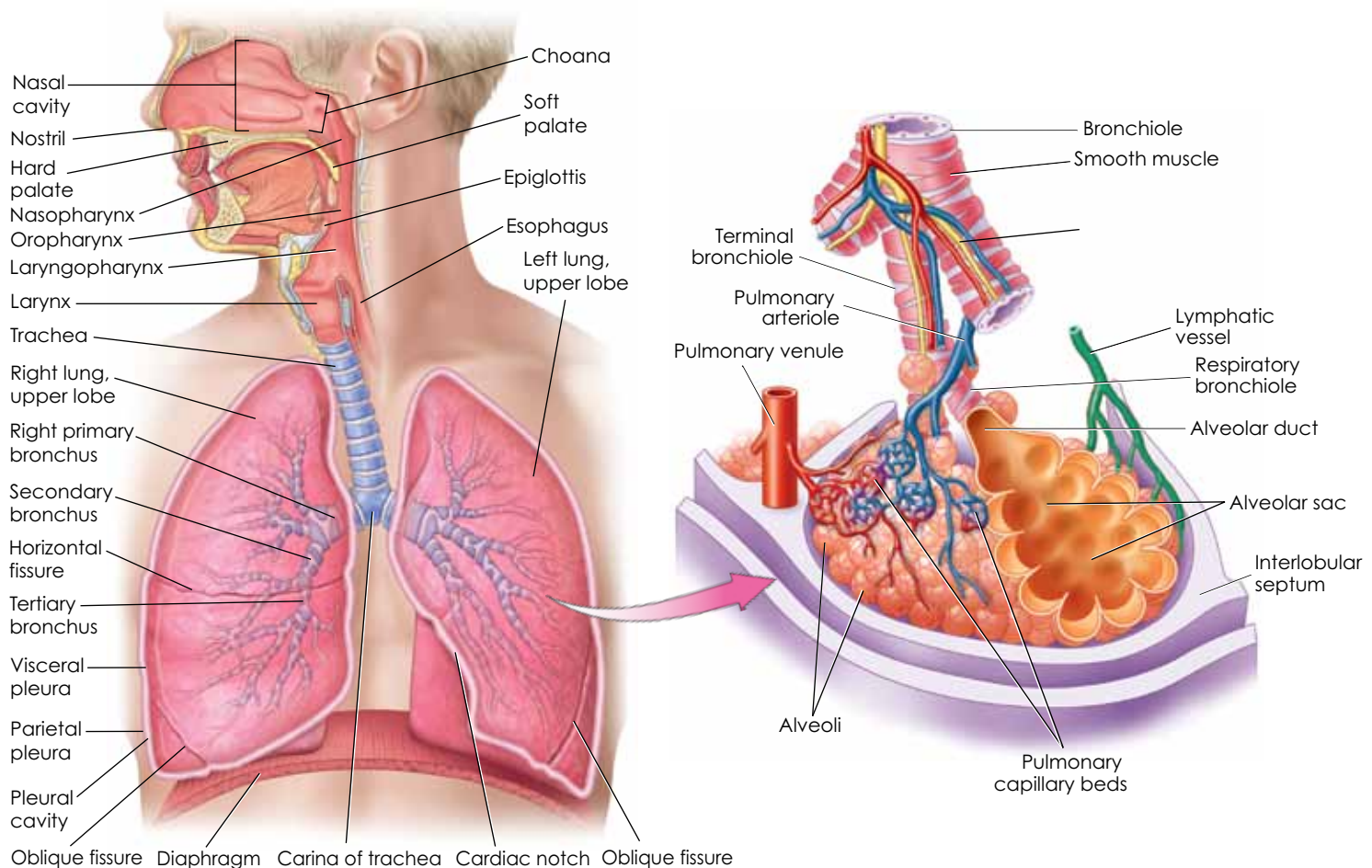
The respiratory system is made up of organs and structures that function together to bring gases in contact with the blood of the circulatory system. This system consists of the **nasal cavity**, **pharynx**, **larynx**, and **trachea**, and the **bronchi**, **bronchioles**, and **pulmonary alveoli** within the lungs (fig. 14.2). The functions of the respiratory system are gas exchange, sound production, assistance in abdominal compression, and coughing and sneezing.

The nasal cavity has a bony and cartilaginous support. The ciliated, mucous lining of the upper respiratory tract warms, moistens, and cleanses inspired air. The **paranasal sinuses** are found in the maxillary, frontal, sphenoid, and ethmoid bones. The **pharynx** is an organ with a funnel-shaped passageway that connects the oral and nasal cavities with the larynx. The cartilaginous **larynx** keeps the passageway to the trachea open during breathing and closes the respiratory passageway during swallowing. It also contains the **vocal folds (vocal cords)**. The **trachea** is a rigid tube, supported by C-rings of cartilage, that leads from the larynx to the **bronchial tree**. **Pulmonary alveoli** are the functional units of the lungs where gas exchange occurs; they are small, numerous, thin-walled air sacs. The right and left **lungs** are separated by the **mediastinum**. Each lung is divided into **lobes** and **lobules** and is contained within a pleural cavity lined by the visceral and parietal pleura.



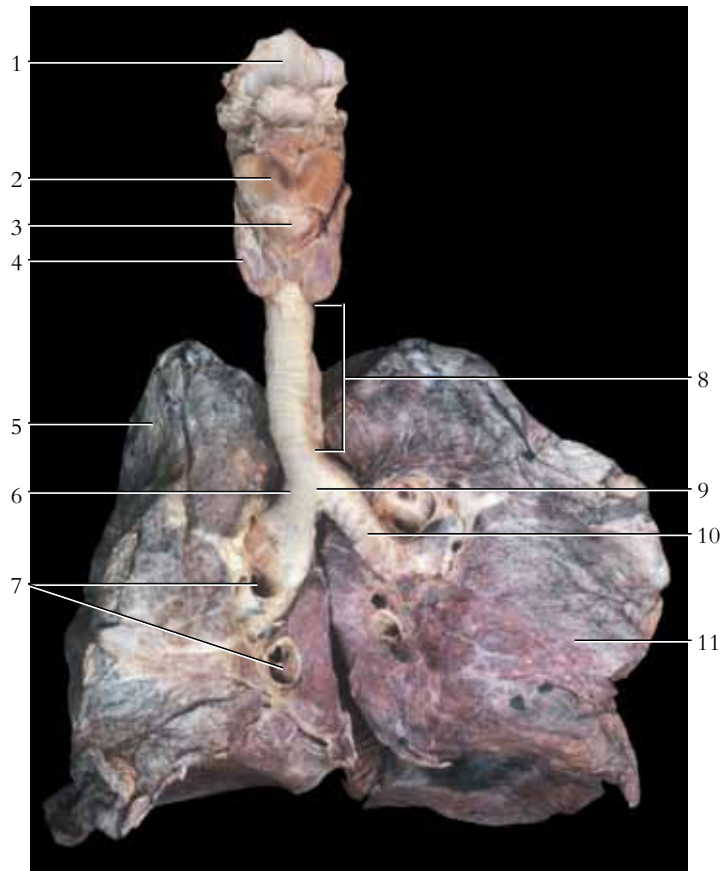
**Figure 14.1** Tracheal wall.

- |                             |                      |
|-----------------------------|----------------------|
| 1. Respiratory epithelium   | 4. Seromucous glands |
| 2. Basement membrane        | 5. Perichondrium     |
| 3. Duct of seromucous gland | 6. Hyaline cartilage |



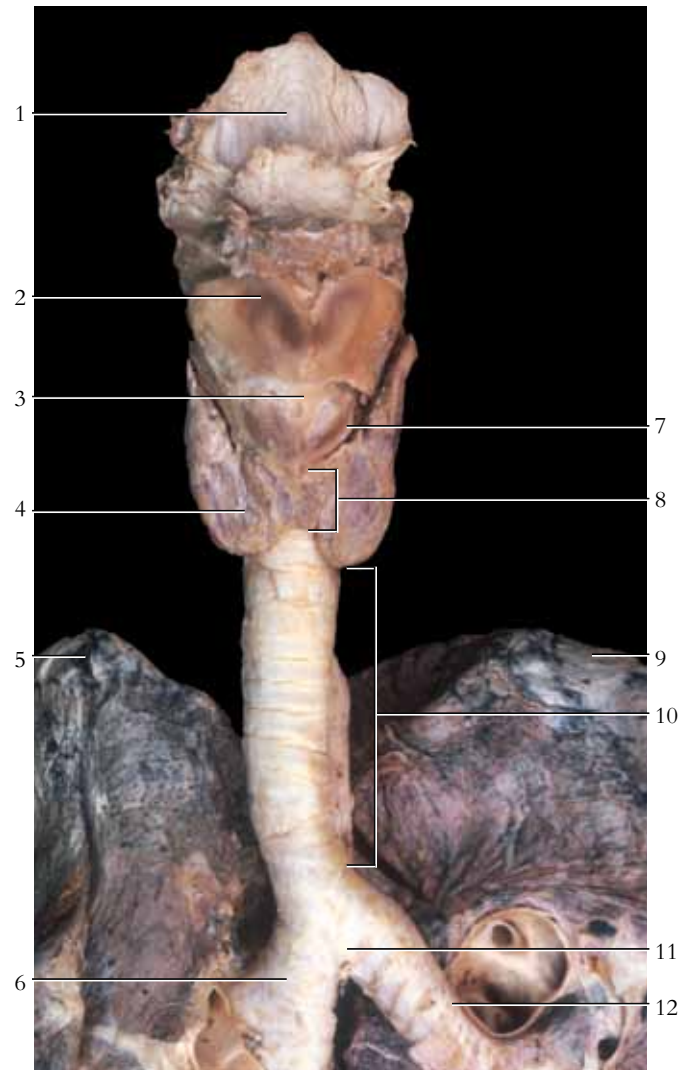
**Figure 14.2** The structure of the respiratory system.





**Figure 14.3** An anterior view of the larynx, trachea, and lungs.

- |                                       |                                       |
|---------------------------------------|---------------------------------------|
| 1. Epiglottis                         | 7. Pulmonary vessels                  |
| 2. Thyroid cartilage                  | 8. Trachea                            |
| 3. Cricoid cartilage                  | 9. Carina                             |
| 4. Thyroid gland                      | 10. Left principal (primary) bronchus |
| 5. Right lung                         | 11. Left lung                         |
| 6. Right principal (primary) bronchus |                                       |



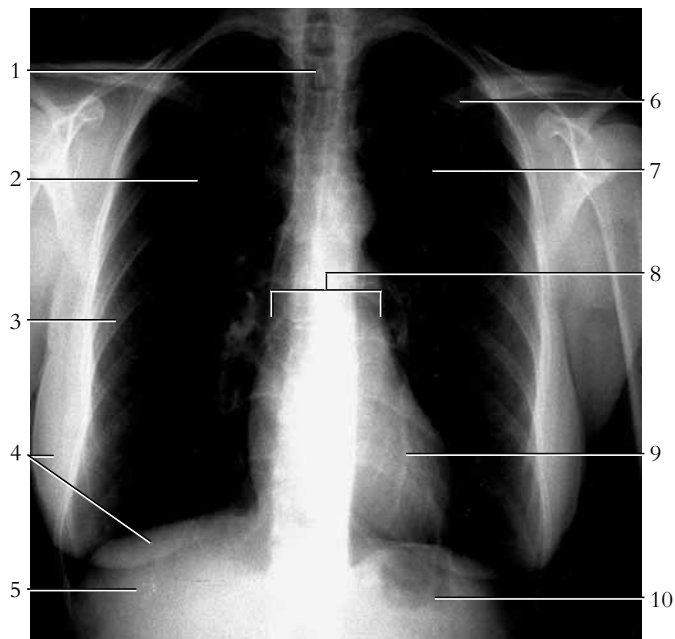
**Figure 14.4** An anterior view of the larynx and trachea.

- |                                       |                                       |
|---------------------------------------|---------------------------------------|
| 1. Epiglottis                         | 7. Cricothyroid ligament              |
| 2. Thyroid cartilage                  | 8. Isthmus of thyroid gland           |
| 3. Cricoid cartilage                  | 9. Superior lobe of left lung         |
| 4. Thyroid gland                      | 10. Trachea                           |
| 5. Superior lobe of right lung        | 11. Carina                            |
| 6. Right principal (primary) bronchus | 12. Left principal (primary) bronchus |



**Figure 14.5** An anterior view of bronchi.

- |  |
|--|
| 1. Trachea                             |
| 2. Apical segmental bronchus           |
| 3. Posterior segmental bronchus        |
| 4. Anterior segmental bronchus         |
| 5. Right principal bronchus            |
| 6. Medial segmental bronchus           |
| 7. Anterior basal segmental bronchus   |
| 8. Carina                              |
| 9. Left principal bronchus             |
| 10. Esophagus                          |
| 11. Medial basal segmental bronchus    |
| 12. Posterior basal segmental bronchus |
| 13. Lateral basal segmental bronchus   |



**Figure 14.6** A radiograph of the thorax.

- |                          |                       |
|--------------------------|-----------------------|
| 1. Thoracic vertebra     | 6. Clavicle           |
| 2. Right lung            | 7. Left lung          |
| 3. Rib                   | 8. Mediastinum        |
| 4. Image of right breast | 9. Heart              |
| 5. Diaphragm/liver       | 10. Diaphragm/stomach |



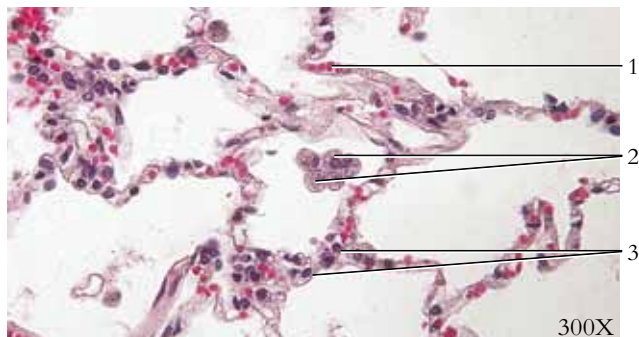
**Figure 14.7** Bronchiole.

- |                        |
|------------------------|
| 1. Pulmonary arteriole |
| 2. Bronchiole          |
| 3. Pulmonary alveoli   |



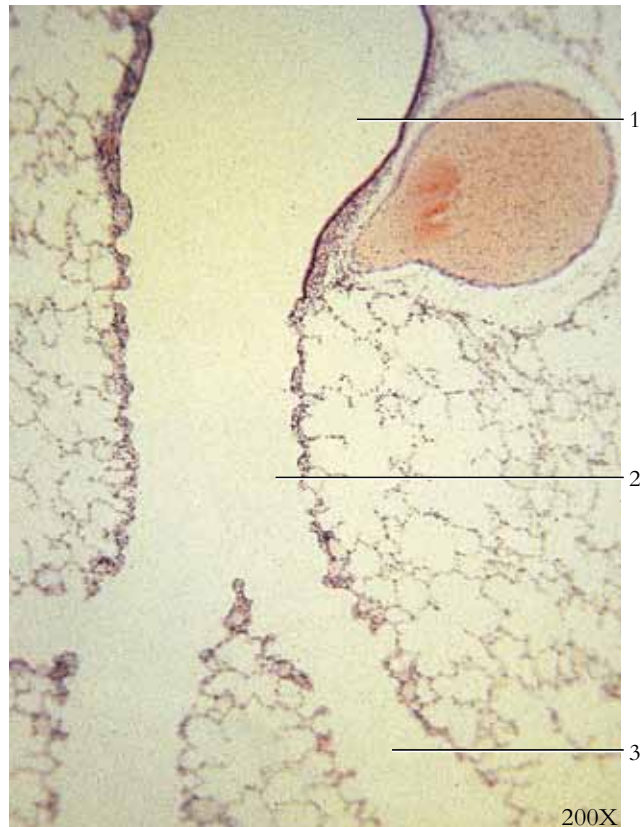
**Figure 14.8** An electron micrograph of the lining of the trachea.

- |          |                |
|----------|----------------|
| 1. Cilia | 2. Goblet cell |
|----------|----------------|



**Figure 14.9** Pulmonary alveoli.

- |                               |                        |
|-------------------------------|------------------------|
| 1. Capillary in alveolar wall | 3. Type II pneumocytes |
| 2. Macrophages                |                        |



**Figure 14.10** Terminal bronchiole.

- |                           |                  |
|---------------------------|------------------|
| 1. Terminal bronchiole    | 3. Alveolar duct |
| 2. Respiratory bronchiole |                  |



# Chapter 15

## Digestive System

The digestive system consists of a **gastrointestinal tract (GI tract)** and **accessory digestive organs**. Most of the food we eat is not suitable for cellular utilization until it is mechanically and chemically reduced to forms that can be absorbed through the intestinal wall and transported to the cells by the blood or lymph. Ingested food is not technically in the body until it is

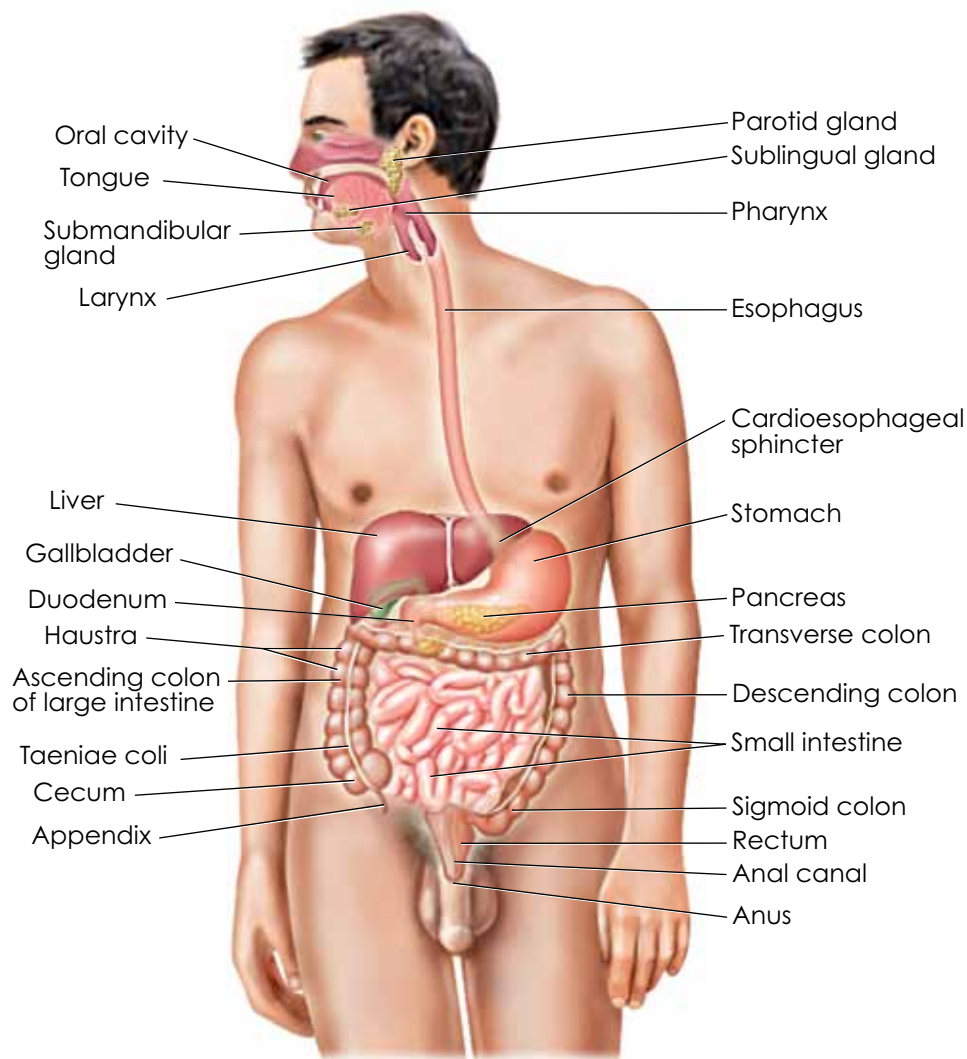
absorbed and, in fact, a large portion of consumed food is not digested at all but rather passes through as fecal material.

The functions of the principal regions and organs of the digestive system are presented in Table-15.1. The digestive system is diagrammed in Figure 15.1.

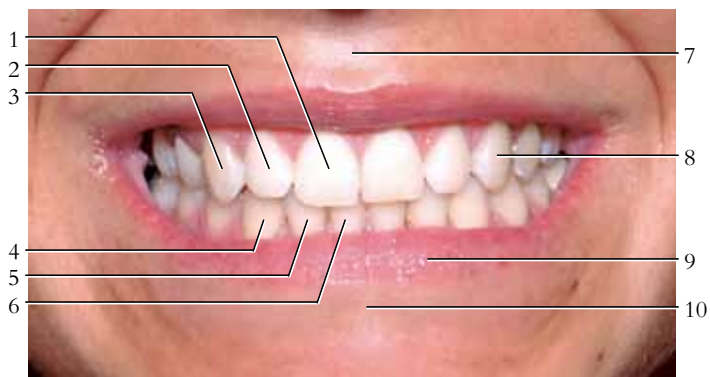
**Table 15.1** Regions and structures of the digestive system.

| Region or Structure               | Function   |
|-----------------------------------|--|
| <b>Gastrointestinal tract</b>     |  |
| Oral cavity                       | Ingests food; receives saliva and initiates digestion of carbohydrates; mastication (chewing); forms bolus (food mass); deglutition (swallowing)   |
| Pharynx                           | Receives bolus from oral cavity and passes it to esophagus   |
| Esophagus                         | Transports bolus to stomach by peristalsis   |
| Stomach                           | Receives bolus from esophagus; forms chyme (paste-like food) initiates digestion of proteins; moves chyme into duodenum; participates in vomiting  |
| Small intestine                   | Receives chyme from stomach, along with secretions from liver and pancreas; chemically and mechanically breaks down chyme; absorbs nutrients; transports wastes to large intestine   |
| Large intestine                   | Receives undigested wastes from small intestine; absorbs water and electrolytes; forms and stores feces, and expels feces through defecation   |
| <b>Accessory digestive organs</b> |  |
| Teeth                             | Mechanically pulverize food  |
| Tongue                            | Manipulate food and assists in swallowing  |
| Salivary glands                   | Secrete saliva which aids in formation of bolus; initiates digestion of carbohydrates  |
| Liver                             | Production of bile; storage of iron and copper; conversion of glucose to glycogen and storage of glycogen; synthesis of certain vitamins; production of urea; synthesis of fibrinogen and prothrombin used for clotting of blood; phagocytosis of foreign material in blood; detoxifies harmful substances in body; storage of blood cells; hemopoiesis in fetus and newborn |
| Gallbladder                       | Concentration and storage of bile necessary for emulsification of fats; releases bile into duodenum  |
| Pancreas                          | Production and secretion of pancreatic juice containing digestive enzymes; production and secretion of the hormones insulin and glucagon   |





**Figure 15.1** The structure of the digestive system.



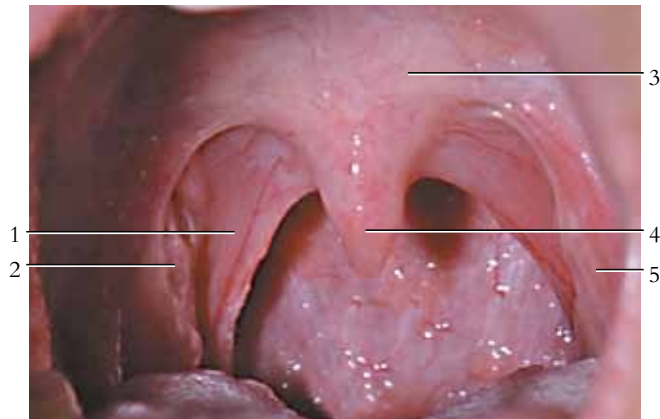
**Figure 15.2** The oral region, lips, and teeth.

- |                             |                             |
|-----------------------------|-----------------------------|
| 1. Medial (central) incisor | 6. Medial (central) incisor |
| 2. Lateral incisor          | 7. Philtrum                 |
| 3. Canine                   | 8. Canine                   |
| 4. Canine                   | 9. Inferior lip             |
| 5. Lateral incisor          | 10. Mentolabial sulcus      |



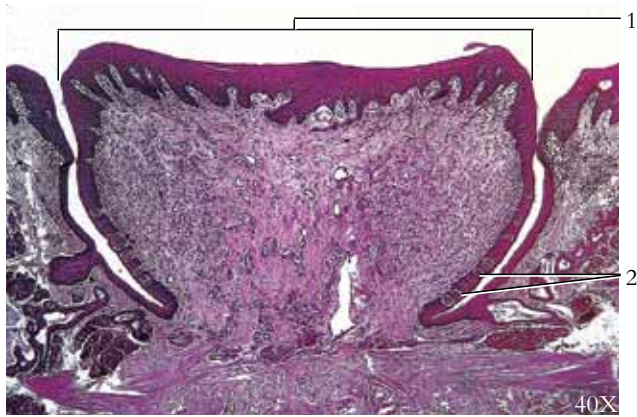
**Figure 15.3** The structures of the oral cavity with the mouth open and the tongue elevated.

- |                     |                                  |
|---------------------|----------------------------------|
| 1. Tongue           | 3. Opening of submandibular duct |
| 2. Lingual frenulum |                                  |



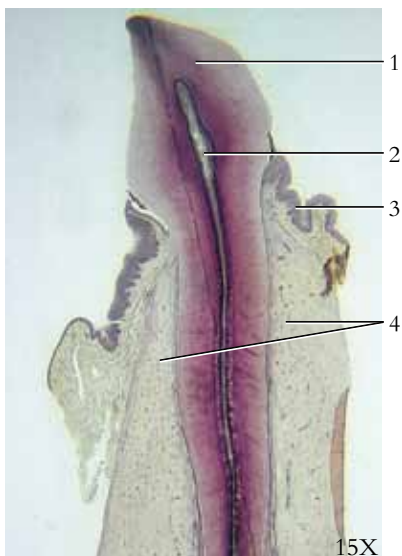
**Figure 15.4** The superficial structures of the oral cavity.

1. Pharyngopalatine arch
2. Palatine tonsil
3. Soft palate
4. Palatine uvula
5. Glossopalatine arch



**Figure 15.6** Vallate papilla

1. Vallate papilla
2. Taste buds



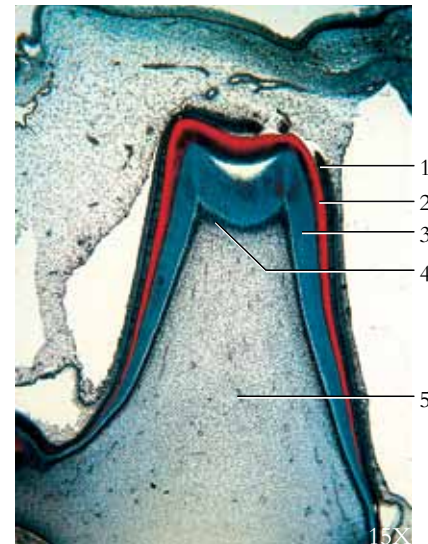
**Figure 15.8** Mature tooth.

1. Dentin (enamel has been dissolved away)
2. Pulp
3. Gingiva
4. Alveolar bone



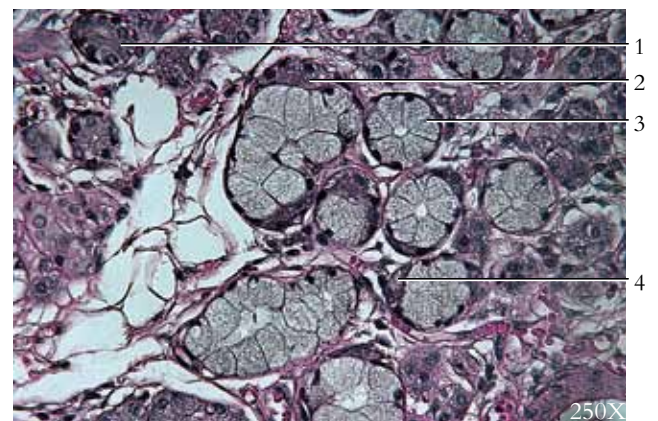
**Figure 15.5** Filiform and fungiform papillae.

1. Filiform papillae
2. Fungiform papilla



**Figure 15.7** Developing tooth.

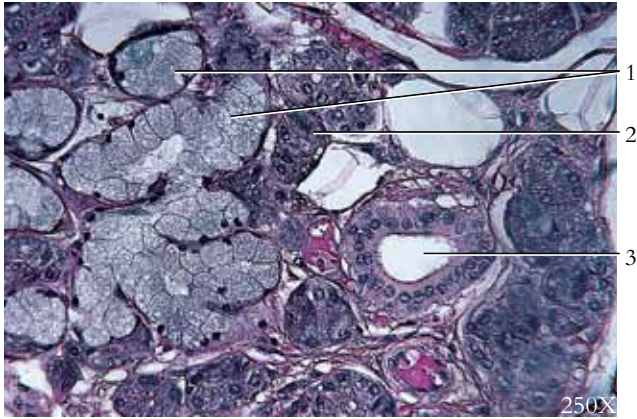
1. Ameloblasts
2. Enamel
3. Dentin
4. Odontoblasts
5. Pulp



**Figure 15.9** Acini of salivary tissue.

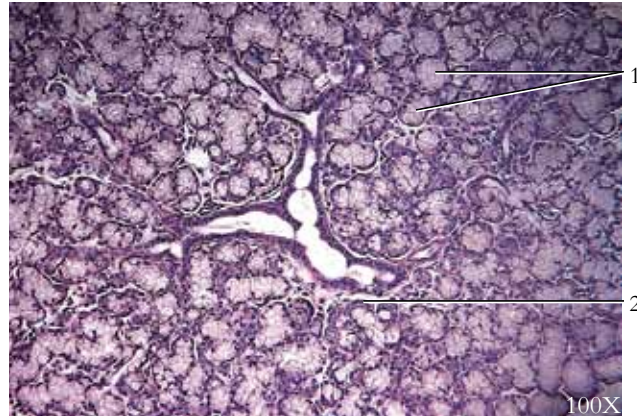
1. Serous acinus
2. Serous demilune on mucous acinus
3. Mucous acinus
4. Serous demilune on mucous acinus





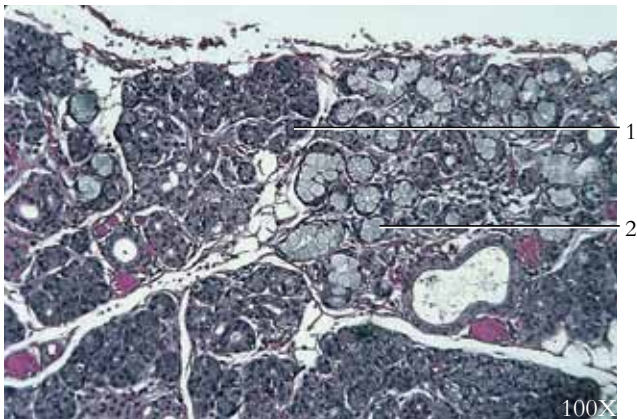
**Figure 15.10** Striated duct.

1. Mucous acini
2. Serous acinus
3. Lumen of striated duct



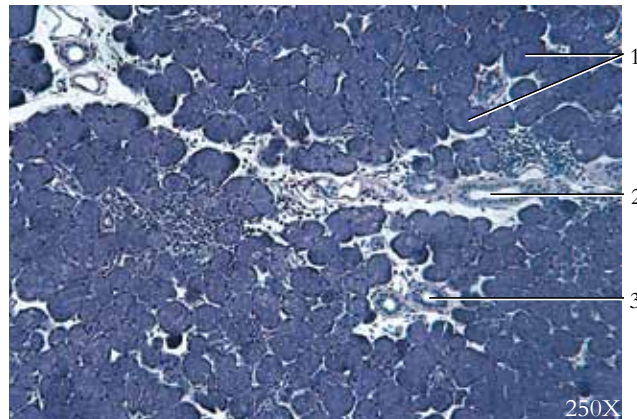
**Figure 15.11** Sublingual gland (mostly mucous, some serous).

1. Mucous acini
2. Serous demilune



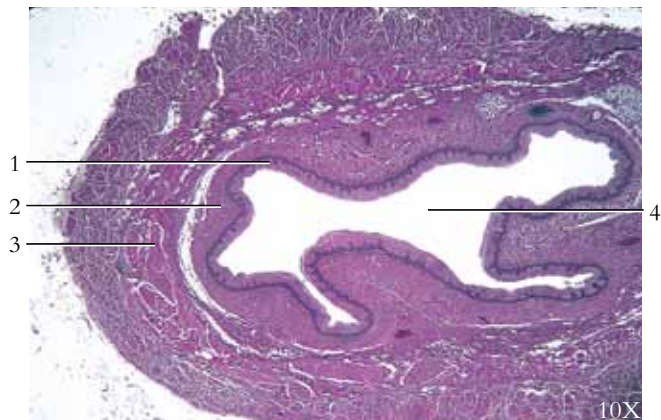
**Figure 15.12** Submandibular gland (about 1/5 mucous and 4/5 serous).

1. Serous acinus
2. Mucous acinus



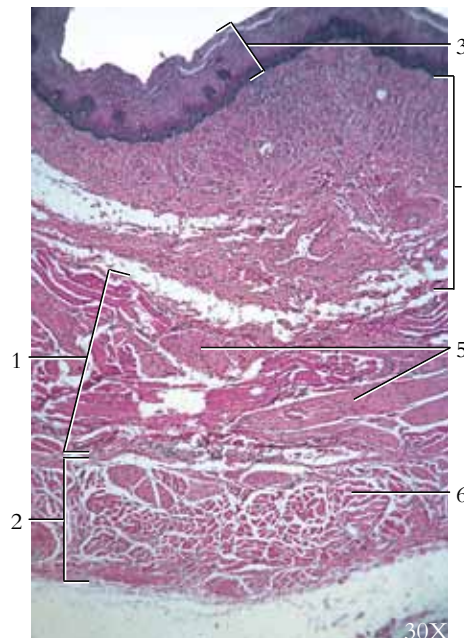
**Figure 15.13** Parotid gland (purely serous).

1. Serous acini
2. Lumen of excretory duct
3. Lumen of striated duct



**Figure 15.14** Cross section of esophagus.

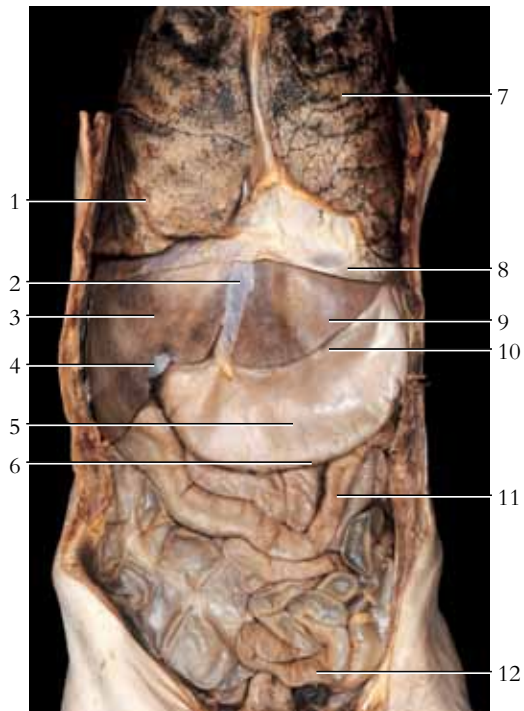
1. Mucosa
2. Submucosa
3. Muscularis externa
4. Lumen



**Figure 15.15** Wall of esophagus.

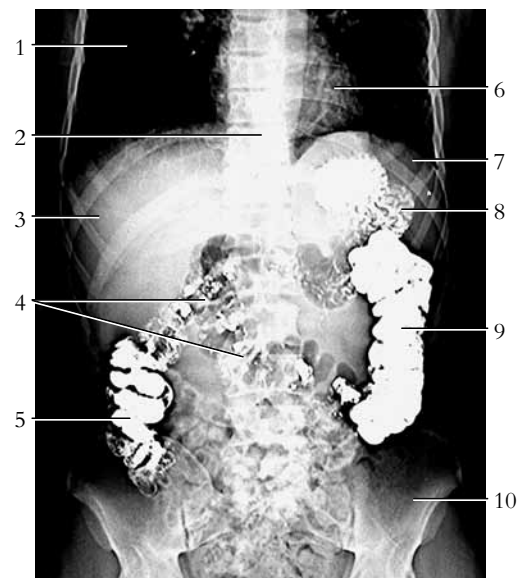
1. Inner circular layer (muscularis externa)
2. Outer longitudinal layer (muscularis externa)
3. Mucosa
4. Submucosa
5. Smooth muscle
6. Skeletal muscle





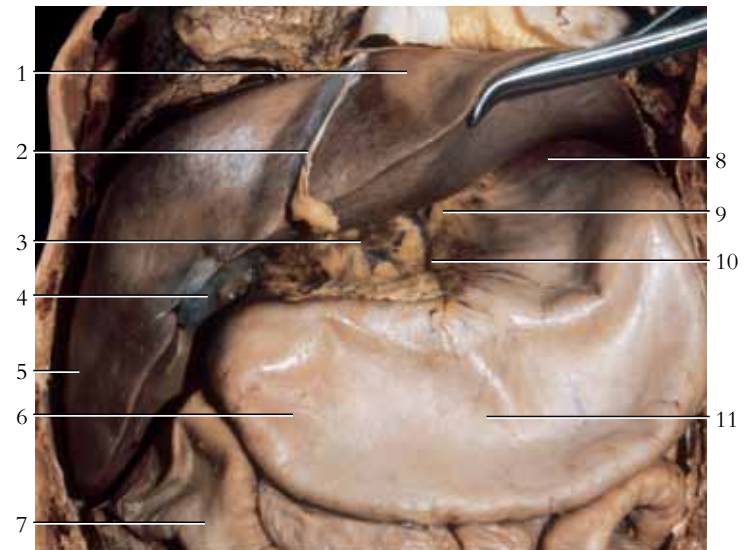
**Figure 15.16** An anterior aspect of the trunk.

- |                                 |                                 |
|---------------------------------|---------------------------------|
| 1. Right lung                   | 7. Left lung                    |
| 2. Falciform ligament           | 8. Diaphragm                    |
| 3. Right lobe of liver          | 9. Left lobe of liver           |
| 4. Gallbladder                  | 10. Lesser curvature of stomach |
| 5. Body of stomach              | 11. Transverse colon            |
| 6. Greater curvature of stomach | 12. Small intestine             |



**Figure 15.18** A CT scanogram of the trunk.

- |                      |                     |
|----------------------|---------------------|
| 1. Right lung        | 5. Ascending colon  |
| 2. Thoracic vertebra | 6. Heart            |
| 3. Liver             | 7. Diaphragm        |
| 4. Small intestine   | 8. Stomach          |
|                      | 9. Descending colon |
|                      | 10. Ilium           |



**Figure 15.17** An anterior view of the stomach and liver.

- |  |   |
|--|---|
| 1. Left lobe of liver (reflected)                    | 6. Pylorus of stomach                         |
| 2. Falciform ligament                                | 7. Transverse colon                           |
| 3. Celiac trunk (covered by hepatoduodenal ligament) | 8. Fundus of stomach                          |
| 4. Gallbladder                                       | 9. Lesser omentum                             |
| 5. Right lobe of liver                               | 10. Gastric vein (traversing through omentum) |
|  | 11. Body of stomach                           |



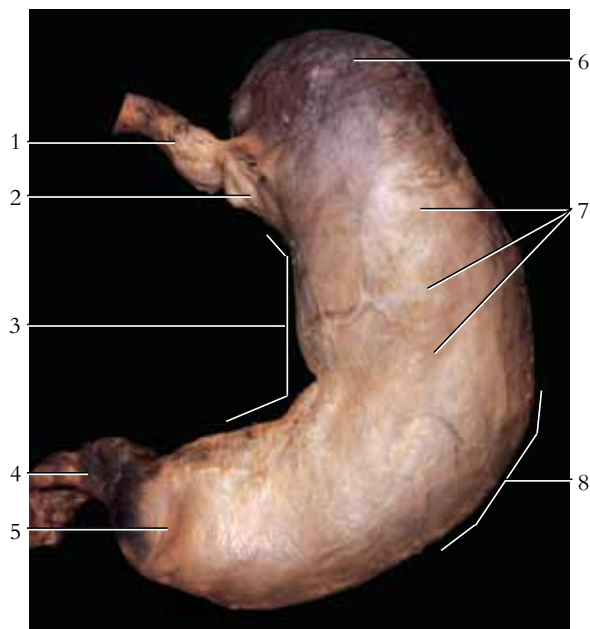
**Figure 15.19** The thoracic and abdominal viscera.

- |  |                    |
|--|--------------------|
| 1. Lungs                                 | 5. Cecum           |
| 2. Heart (surrounded by pericardial fat) | 6. Vagus nerves    |
| 3. Diaphragm                             | 7. Phrenic nerves  |
| 4. Liver                                 | 8. Small intestine |



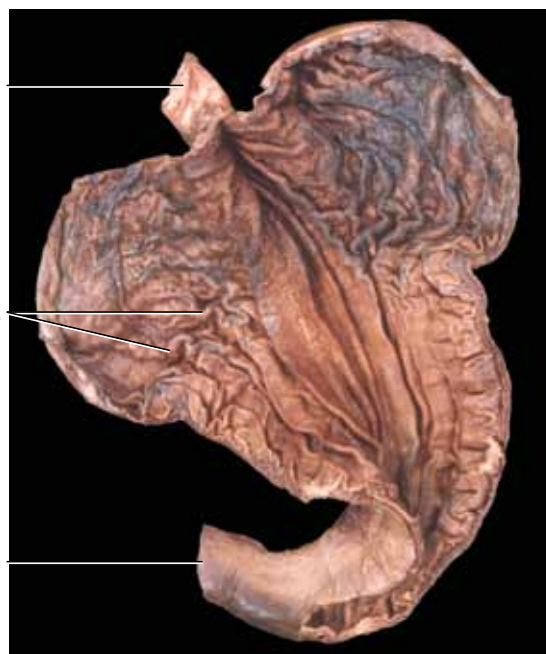
**Figure 15.20** The upper abdominal organs. The greater omentum has been removed and the stomach reflected.

- |                                  |   |                                  |
|----------------------------------|---|----------------------------------|
| 1. Right lobe of liver           | 5. Mesentery                                | 8. Pancreas                      |
| 2. Duodenum                      | 6. Greater curvature of stomach (reflected) | 9. Transverse colon              |
| 3. Taenia coli                   | 7. Lesser omentum                           | 10. Left colic (splenic) flexure |
| 4. Right colic (hepatic) flexure |   | 11. Small intestine              |



**Figure 15.21** The major regions and structures of the stomach.

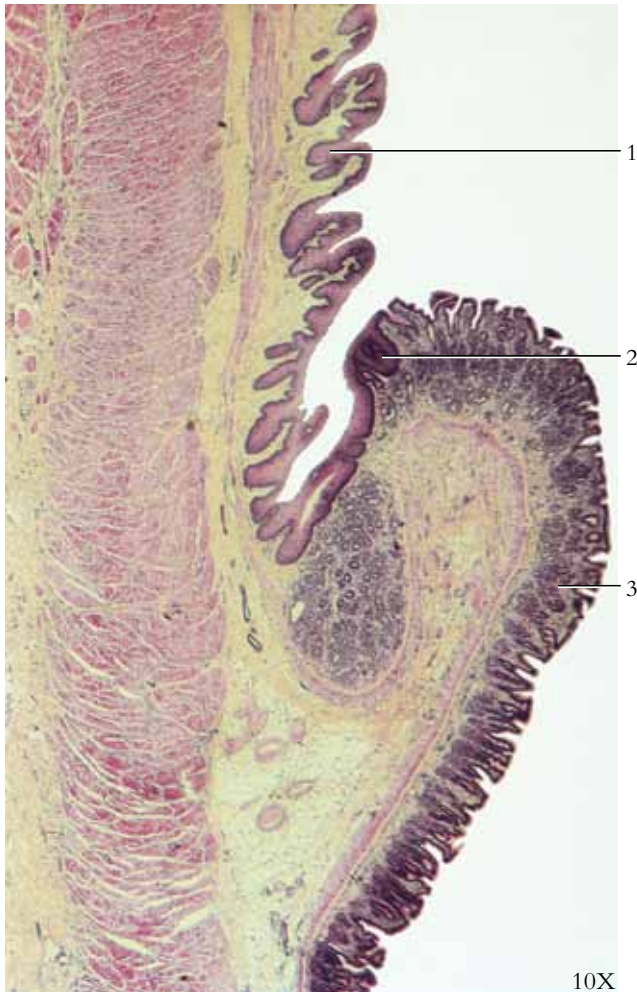
- |                                |                                 |
|--------------------------------|---------------------------------|
| 1. Esophagus                   | 5. Pylorus of stomach           |
| 2. Cardiac portion of stomach  | 6. Fundus of stomach            |
| 3. Lesser curvature of stomach | 7. Body of stomach              |
| 4. Duodenum                    | 8. Greater curvature of stomach |



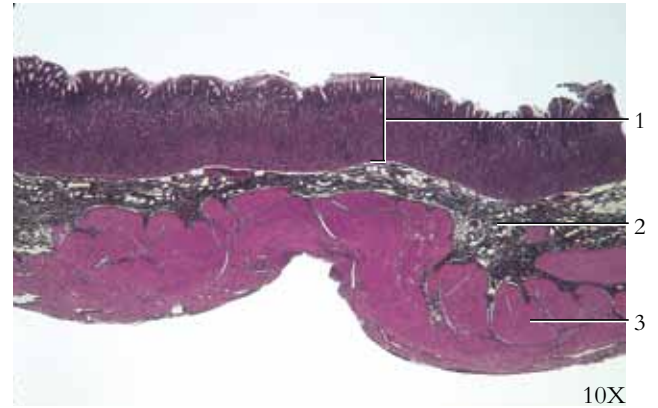
**Figure 15.22** The interior aspect of the stomach.

- |                          |
|--------------------------|
| 1. Esophagus             |
| 2. Gastric folds (rugae) |
| 3. Duodenum              |

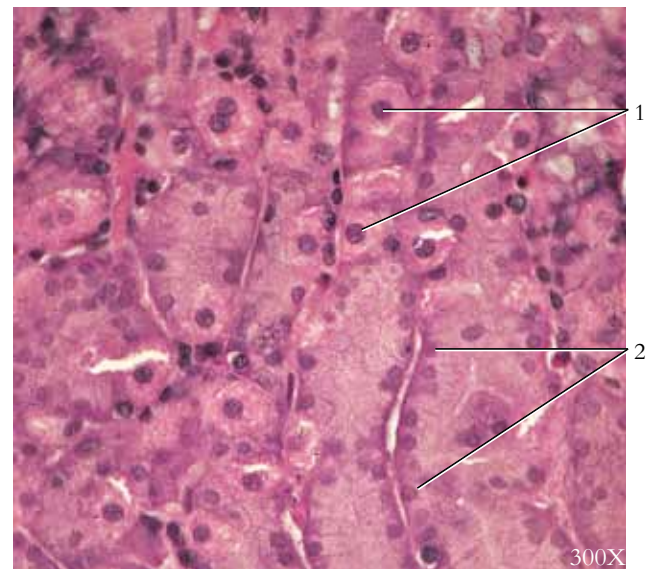


**Figure 15.23** Junction of esophagus and stomach.

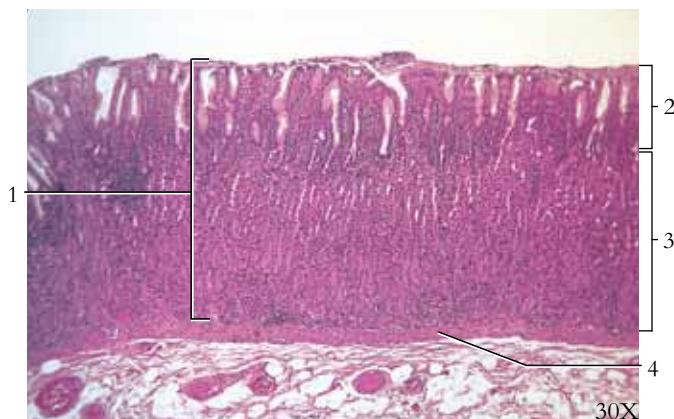
1. Epithelium of esophagus
2. Abrupt change in epithelium
3. Epithelium of stomach

**Figure 15.24** Wall of stomach.

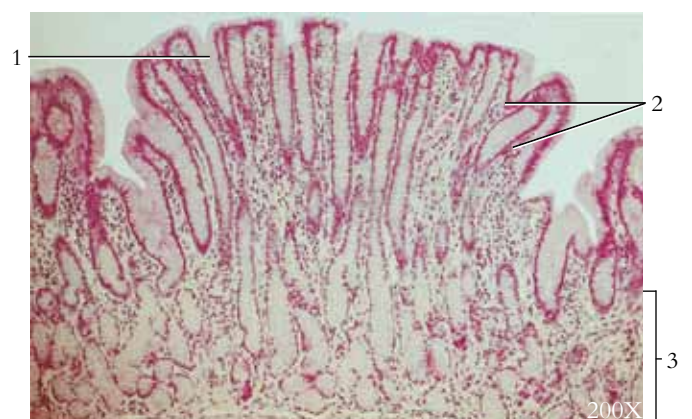
1. Mucosa
2. Submucosa
3. Muscularis externa

**Figure 15.25** Gastric glands.

1. Parietal cells
2. Chief cells

**Figure 15.26** Mucosa of stomach body.

1. Mucosa
2. Gastric pits
3. Gastric glands
4. Muscularis mucosae

**Figure 15.27** Mucosa of stomach pylorus.

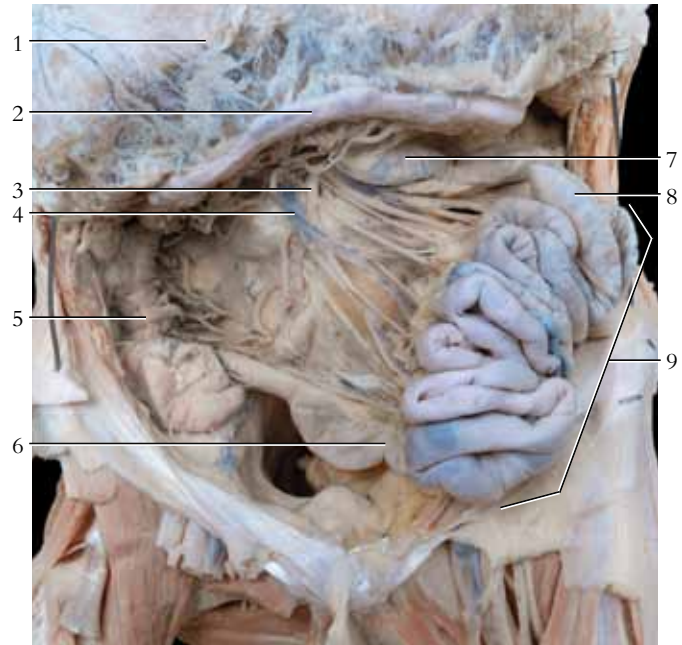
1. Gastric pit
2. Lamina propria
3. Gastric glands





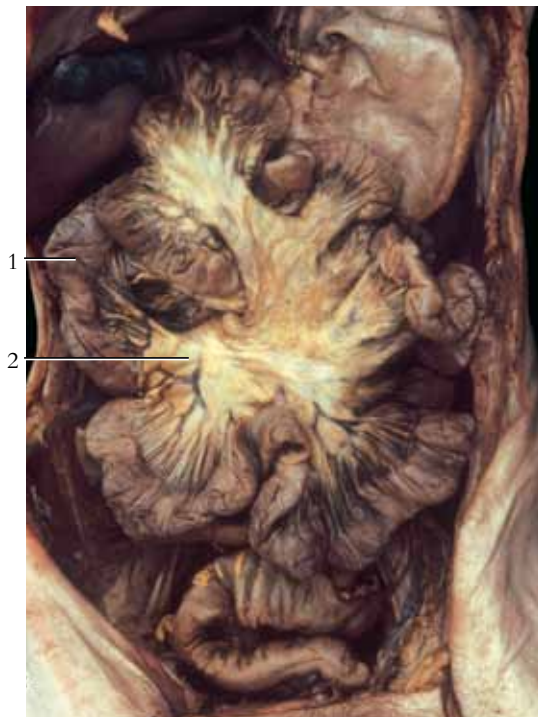
**Figure 15.28** An anterior aspect of the small and large intestines with associated structures.

- |                                 |                        |
|---------------------------------|------------------------|
| 1. Taeniae coli                 | 5. Transverse colon    |
| 2. Appendix                     | 6. Small intestine     |
| 3. Cecum                        | 7. Epiploic appendages |
| 4. Left colic (splenic) flexure |                        |



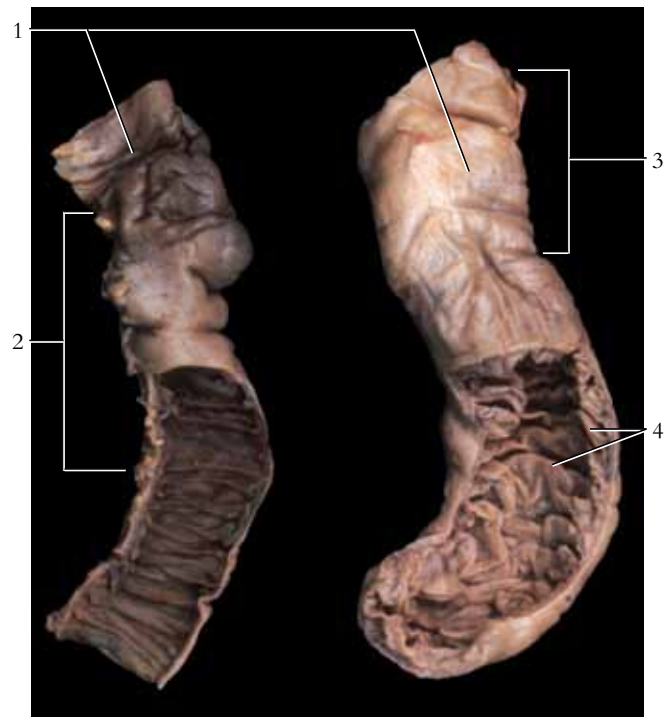
**Figure 15.29** An anterior aspect of the small and large intestines with associated structures.

- |                                 |                                |
|---------------------------------|--------------------------------|
| 1. Greater omentum (reflected)  | 6. Ileum                       |
| 2. Transverse colon (reflected) | 7. Stomach                     |
| 3. Superior mesenteric artery   | 8. Jejunum                     |
| 4. Superior mesenteric vein     | 9. Small intestine (reflected) |
| 5. Ascending colon              |                                |



**Figure 15.30** The mesentery and small intestine within abdominal cavity.

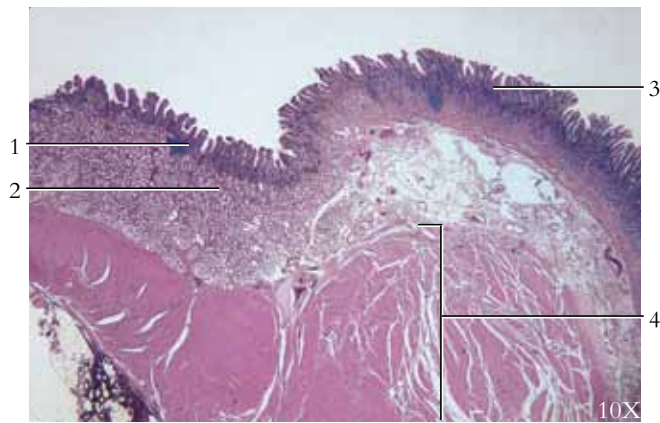
- |                                 |
|---------------------------------|
| 1. Serosa (visceral peritoneum) |
| 2. Mesentery                    |



**Figure 15.31** Sections of the small intestine.

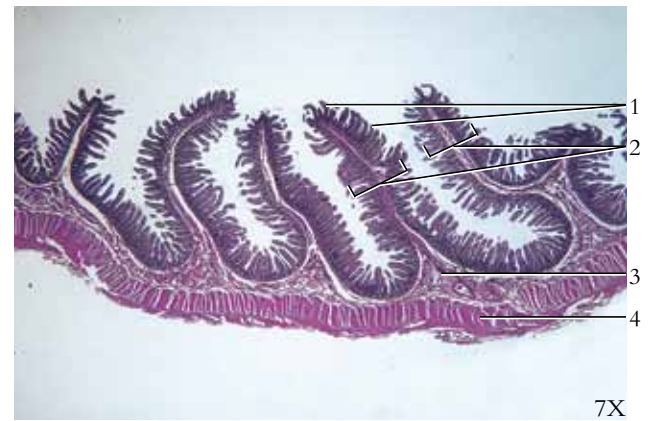
- |                                 |                      |
|---------------------------------|----------------------|
| 1. Serosa (visceral peritoneum) | 3. Jejunum           |
| 2. Ileum                        | 4. Plicae circulares |





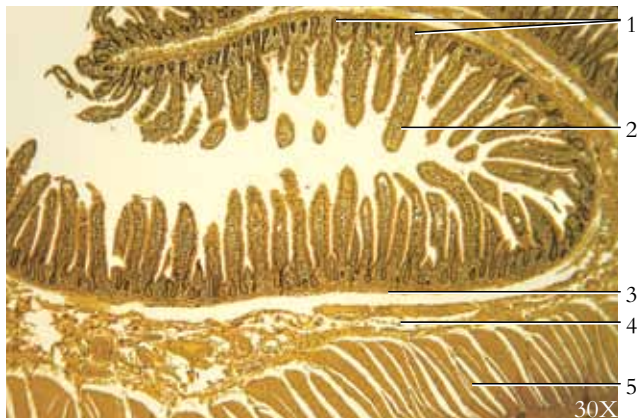
**Figure 15.32** Junction of pylorus and duodenum.

- |                                |                       |
|--------------------------------|-----------------------|
| 1. Duodenal epithelium         | 3. Stomach epithelium |
| 2. Duodenal (Brunner's) glands | 4. Pyloric sphincter  |



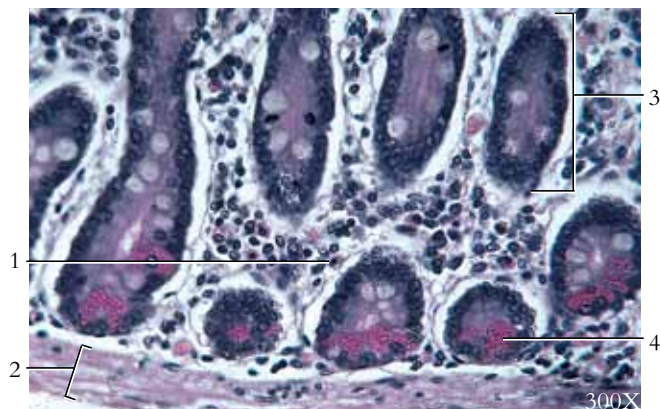
**Figure 15.33** Small intestine.

- |                      |                       |
|----------------------|-----------------------|
| 1. Intestinal villi  | 3. Submucosa          |
| 2. Plicae circulares | 4. Muscularis externa |



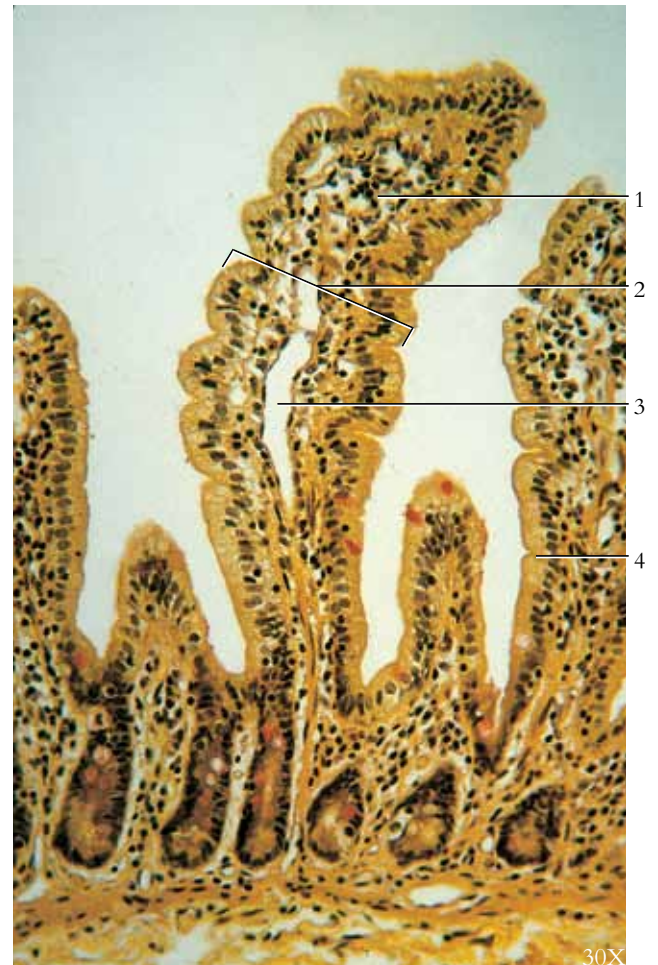
**Figure 15.34** Small intestine.

- |                       |                       |
|-----------------------|-----------------------|
| 1. Intestinal glands  | 4. Submucosa          |
| 2. Intestinal villi   | 5. Muscularis externa |
| 3. Muscularis mucosae |                       |



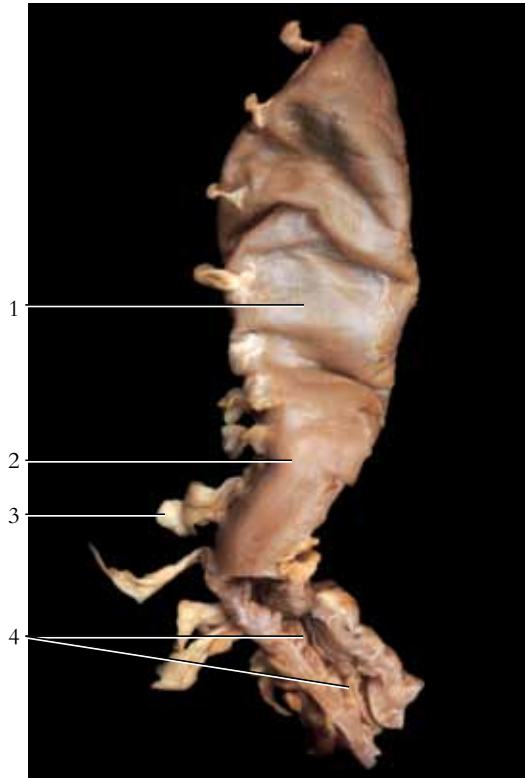
**Figure 15.35** Intestinal glands.

- |                                     |                     |
|-------------------------------------|---------------------|
| 1. Eosinophil within lamina propria | 3. Intestinal gland |
| 2. Muscularis mucosae               | 4. Paneth cells     |



**Figure 15.36** Intestinal villus.

- |                      |   |
|----------------------|---|
| 1. Lamina propria    | 4. Mucosa of simple columnar epithelium |
| 2. Intestinal villus |   |
| 3. Central lacteal   |   |



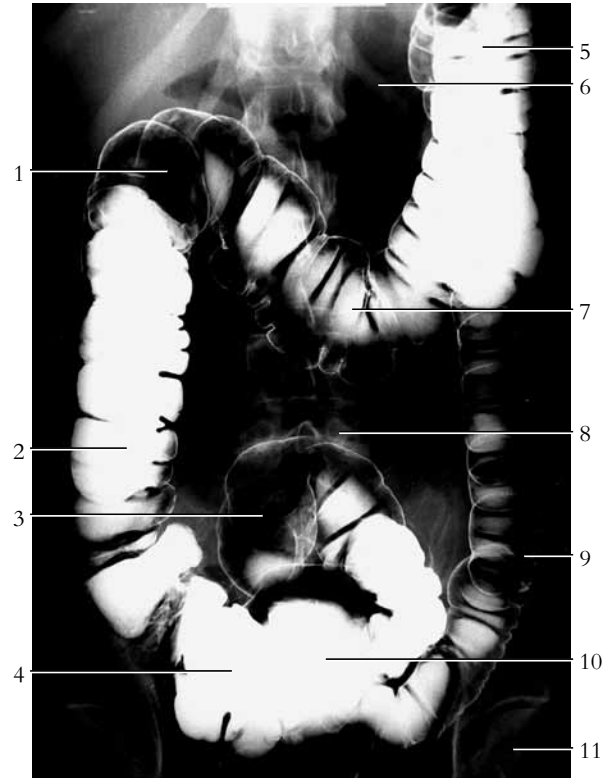
**Figure 15.37** A section of the large intestine (colon).

1. Haustrum
2. Taeniae coli
3. Epiploic appendage
4. Semilunar folds (plicae) of colon



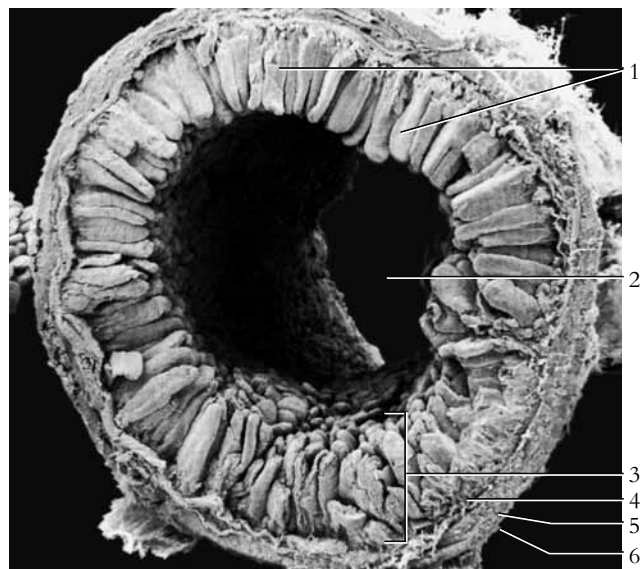
**Figure 15.39** The cecum and appendix.

1. Ascending colon
2. Taeniae coli
3. Cecum
4. Ileum
5. Appendix



**Figure 15.38** A radiograph of the large intestine.

1. Right colon (hepatic) flexure
2. Ascending colon
3. Sigmoid colon
4. Cecum
5. Left colic (splenic) flexure
6. 12th rib
7. Transverse colon
8. Lumbar vertebra
9. Descending colon
10. Rectum
11. Hip joint



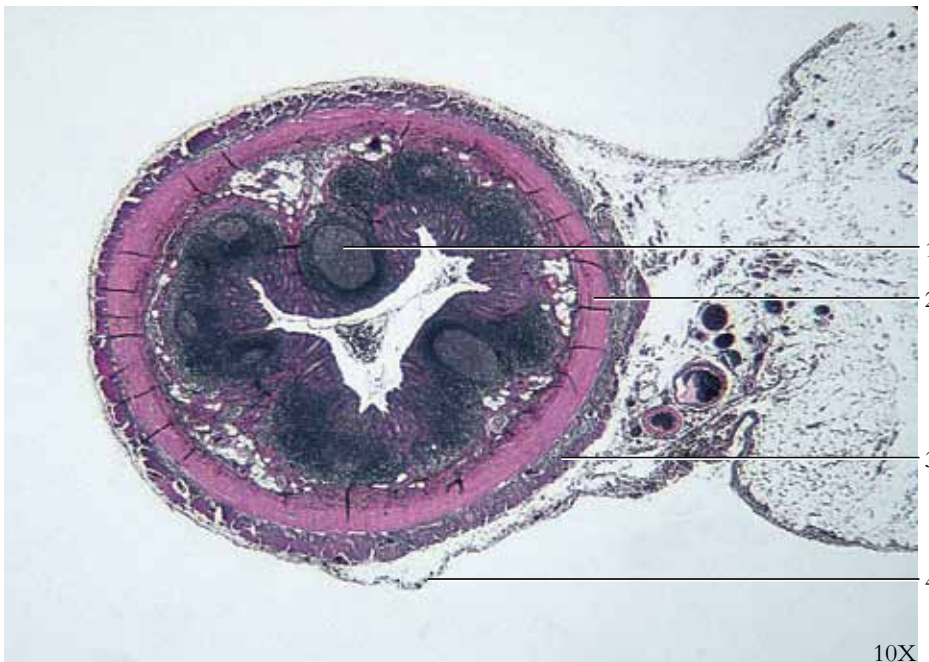
**Figure 15.40** An electron micrograph of the ileum, shown in cross section.

1. Intestinal villi
2. Lumen
3. Mucosa
4. Submucosa
5. Tunica muscularis
6. Adventitia



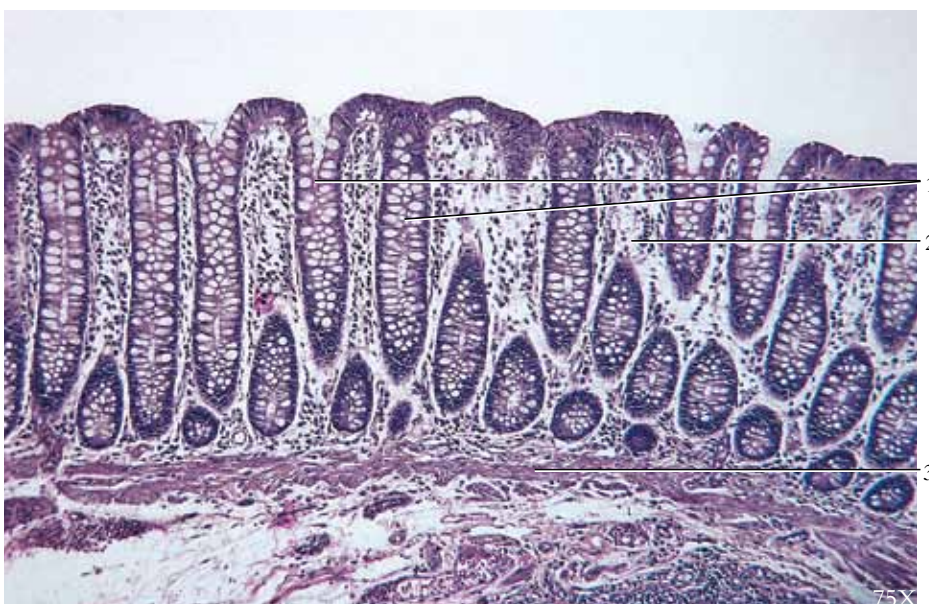


**Figure 15.41** An inflamed appendix that has been removed in an appendectomy. The chief danger of appendicitis is that the appendix might rupture and produce peritonitis.



**Figure 15.42** Appendix, shown in cross section.

1. Lymphatic nodule
2. Circular layer of muscularis externa
3. Longitudinal layer of muscularis externa
4. Serosa (visceral peritoneum)



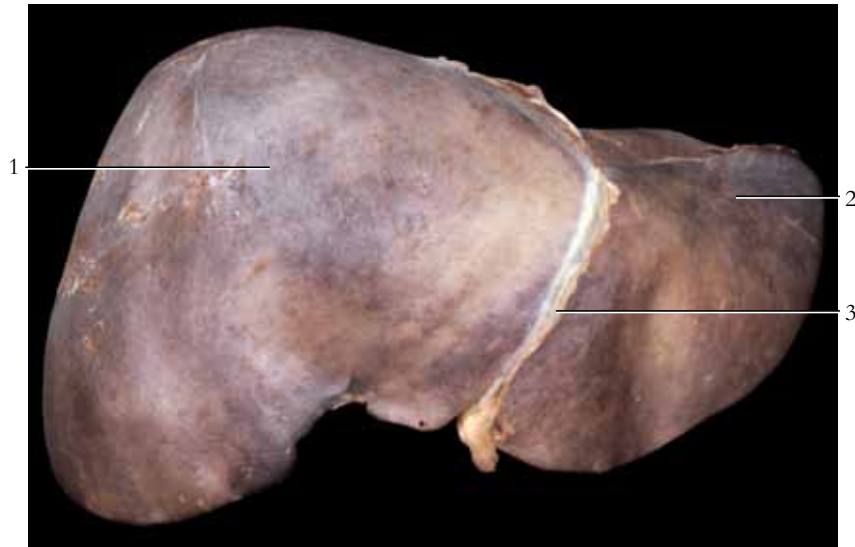
**Figure 15.43** Large intestine.

1. Glands
2. Lamina propria
3. Muscularis mucosae



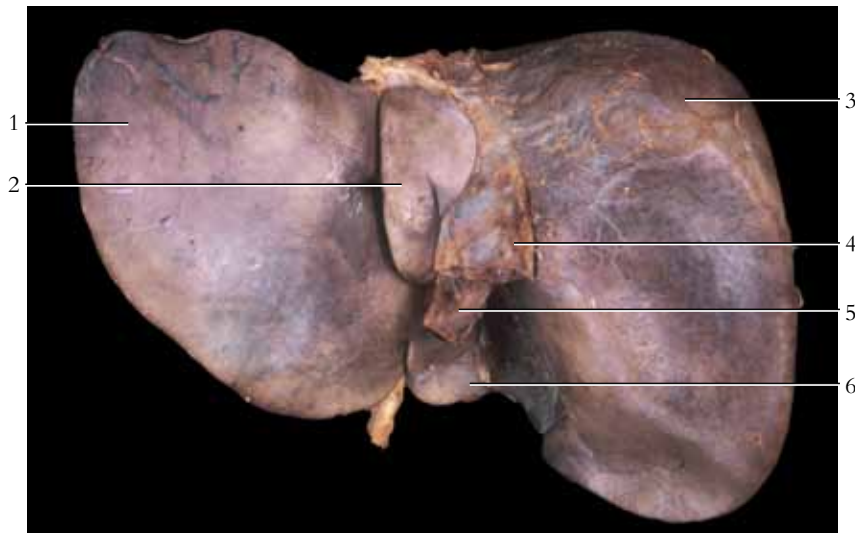
**Figure 15.44** An inferior view of the liver and gallbladder.

1. Gallbladder
2. Right lobe of liver
3. Cystic duct
4. Hepatic duct
5. Common bile duct
6. Falciform ligament
7. Left lobe of liver
8. Hepatic artery
9. Caudate lobe of liver
10. Hepatic portal vein



**Figure 15.45** An anterior view of the liver.

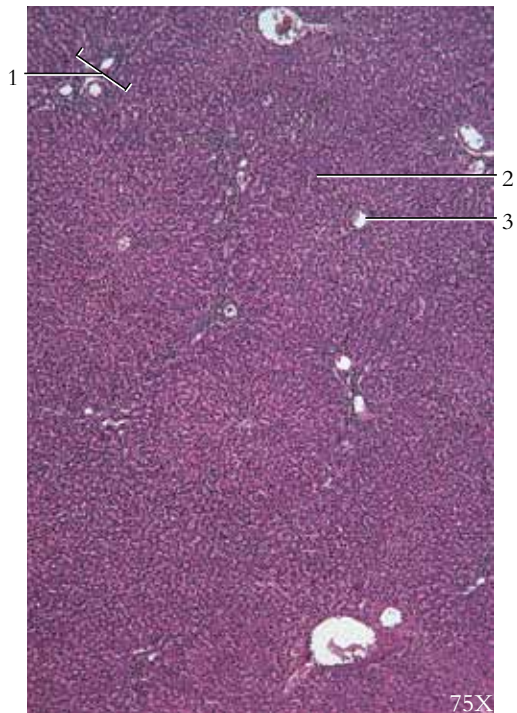
1. Right lobe of liver
2. Left lobe of liver
3. Falciform ligament



**Figure 15.46** An inferior view of the liver.

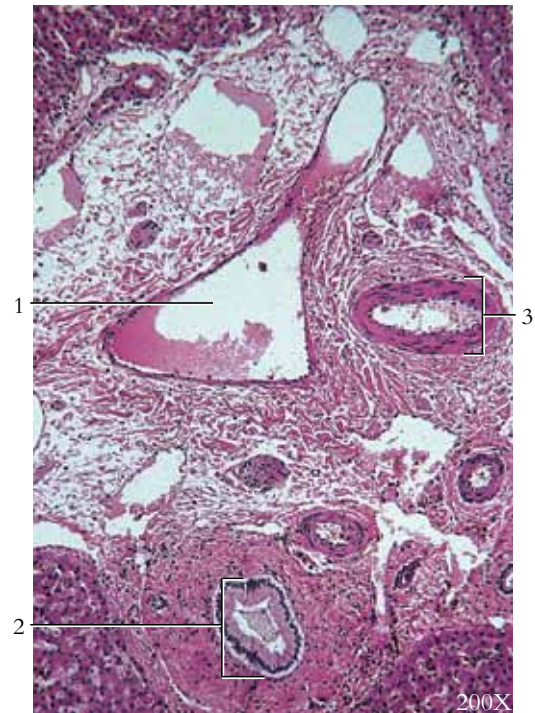
1. Left lobe of liver
2. Caudate lobe of liver
3. Right lobe of liver
4. Inferior vena cava
5. Hepatic portal vein
6. Quadrate lobe of liver





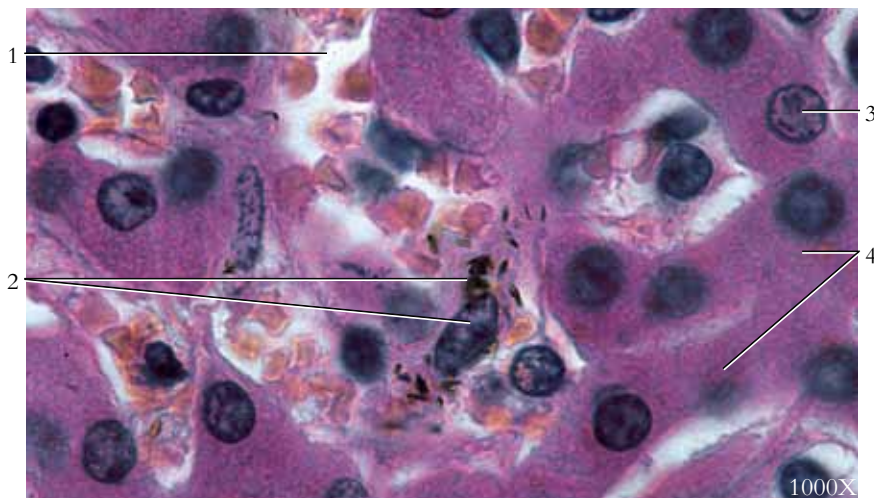
**Figure 15.47** Hepatic lobules.

1. Portal area
2. Hepatic lobule
3. Central vein



**Figure 15.48** Portal area.

1. Lumen of portal vein
2. Bile duct
3. Hepatic artery



**Figure 15.49** Hepatic plates.

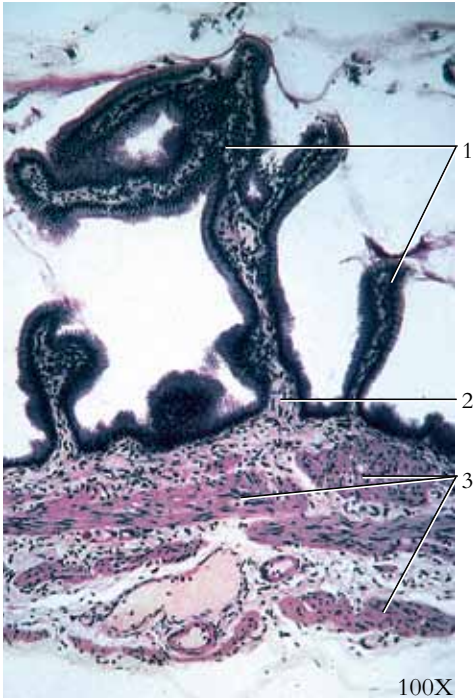
1. Sinusoid containing red blood cells
2. Kupffer cell with debris in its cytoplasm
3. Hepatocyte nucleus
4. Plate of hepatocytes



**Figure 15.50** A gallbladder that has been removed (cholecystectomy) and cut open to remove its gallstone (biliary calculus).

1. Gallbladder
2. Gallstone





**Figure 15.51** Gallbladder.

1. Mucosal folds
2. Lamina propria
3. Muscularis



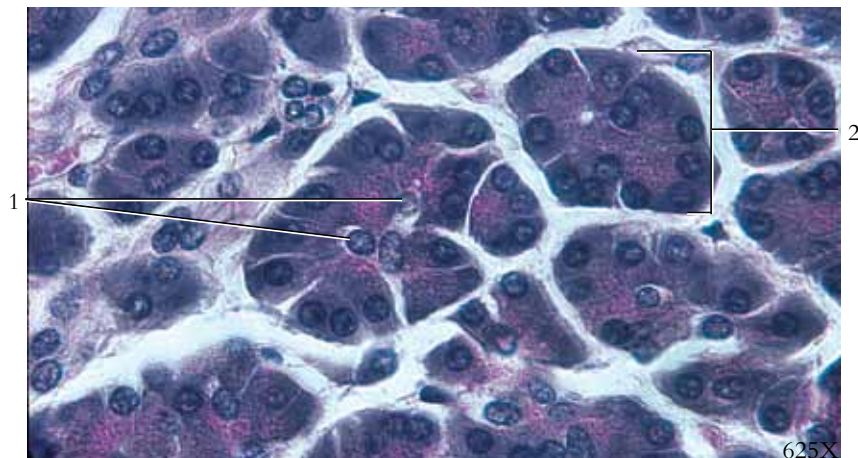
**Figure 15.52** An anterior view of abdominal cavity showing pancreas and associated structures with overlying viscera removed.

1. Liver (reflected)
2. Stomach (reflected)
3. Gallbladder
4. Pancreas
5. Duodenum
6. Diaphragm
7. Spleen
8. Adrenal gland
9. Kidney



**Figure 15.53** An anterior view of the pancreas and pancreatic duct.

1. Duodenum
2. Body of pancreas
3. Pancreatic duct
4. Head of pancreas
5. Tail of pancreas



**Figure 15.54** Pancreatic acini.

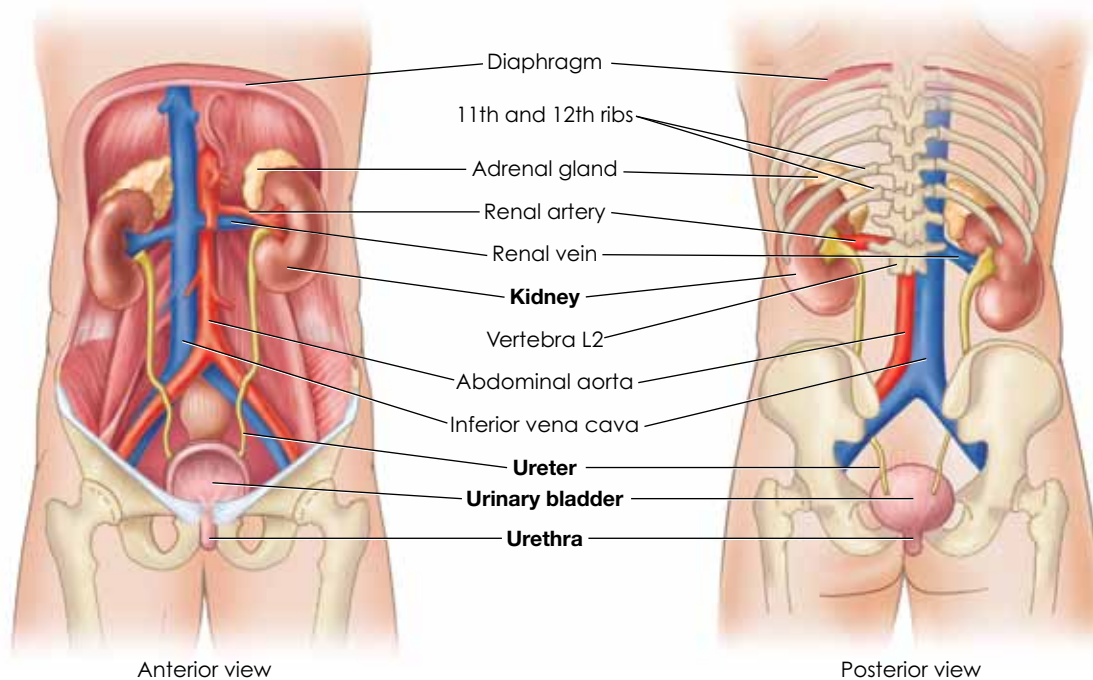
1. Centroacinar cells
2. Acinus

# Chapter 16

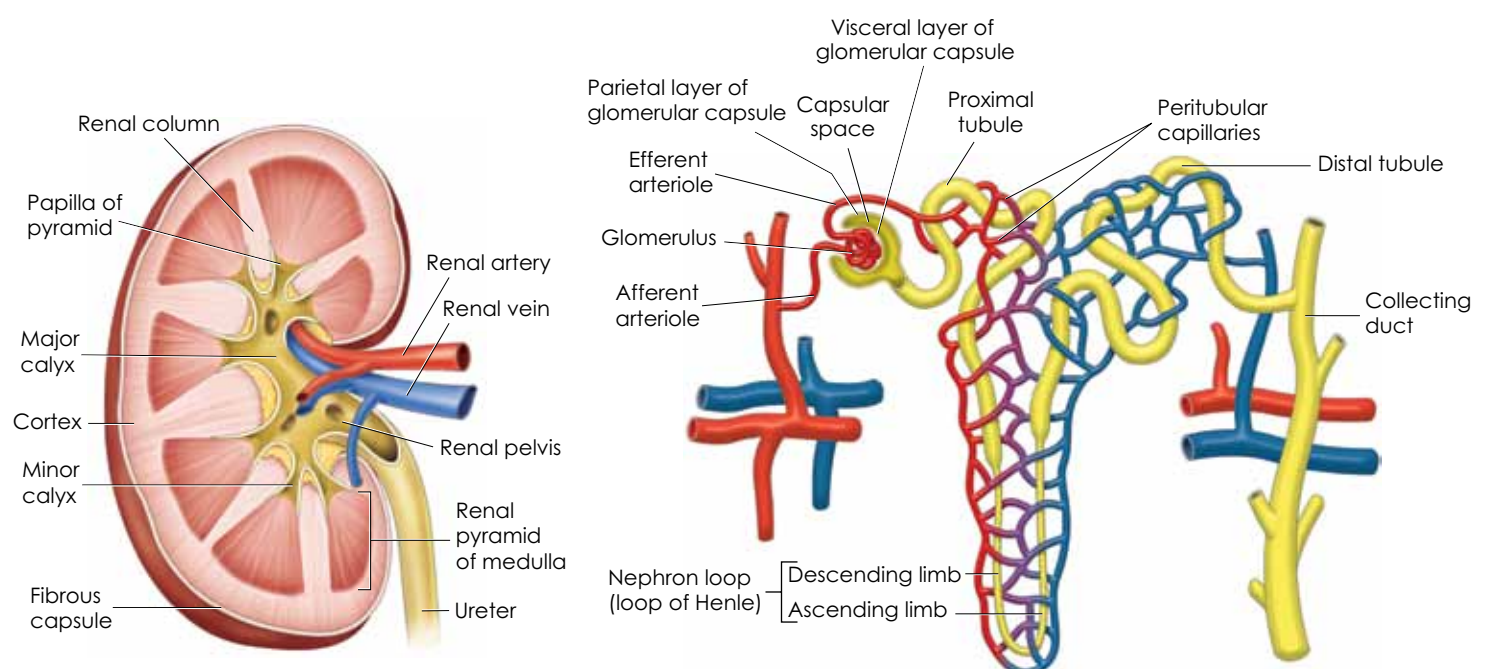
## Urinary System

The urinary system consists of the **kidneys**, **ureters**, **urinary bladder**, and **urethra** (fig. 16.1). The urinary system: 1) removes metabolic wastes from the blood and excretes it (as urine) to the outside during micturition (the physiological aspect of urination); 2) regulates, in part, the rate of red blood

cell formation by secretion of the hormone **erythropoietin**; 3) assists the regulation of blood pressure by secreting the enzyme **renin**; 4) assists the regulation of calcium by activating vitamin D; and 5) assists the regulation of the volume, composition, and pH of body fluids.



**Figure 16.1** The organs of the urinary system.



**Figure 16.2** The structure of the kidney.

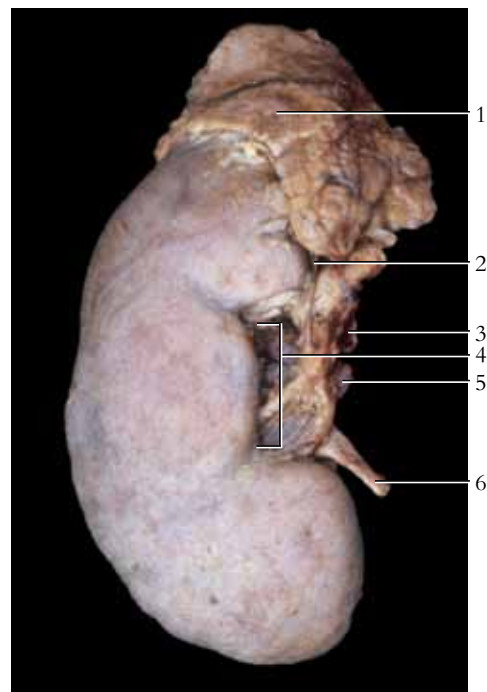
**Figure 16.3** The structure of the nephron.





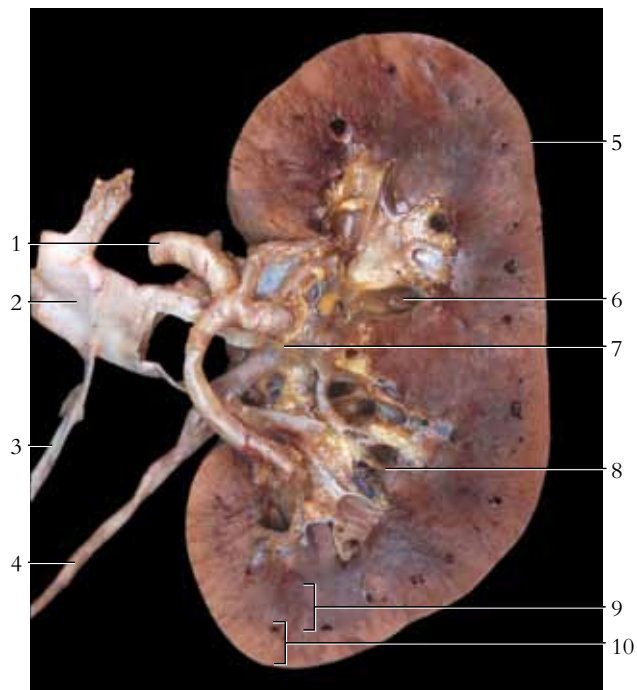
**Figure 16.4** The kidney and ureter with overlying viscera removed.

- |                  |                              |
|------------------|------------------------------|
| 1. Liver         | 6. Quadratus lumborum muscle |
| 2. Adrenal gland | 7. Gallbladder               |
| 3. Renal artery  | 8. Inferior vena cava        |
| 4. Renal vein    | 9. Ureter                    |
| 5. Right kidney  |                              |



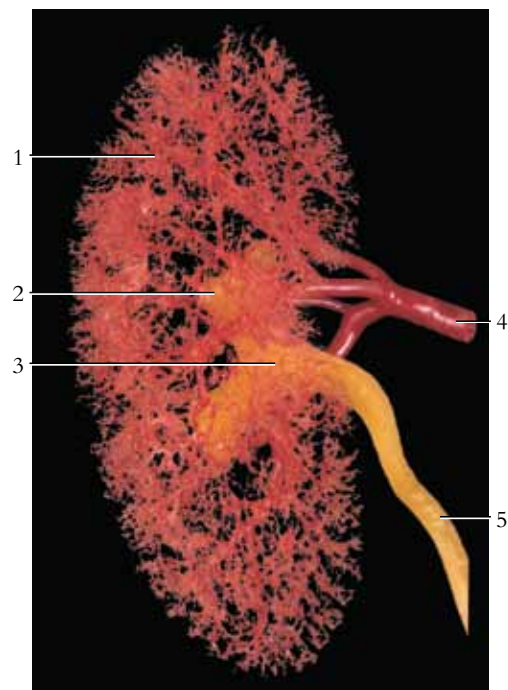
**Figure 16.5** An anterior view of the right kidney.

- |                      |               |
|----------------------|---------------|
| 1. Adrenal gland     | 4. Hilum      |
| 2. Suprarenal artery | 5. Renal vein |
| 3. Renal artery      | 6. Ureter     |



**Figure 16.6** A coronal section of the left kidney.

- |                         |                  |
|-------------------------|------------------|
| 1. Renal artery         | 6. Major calyx   |
| 2. Renal vein           | 7. Renal pelvis  |
| 3. Left testicular vein | 8. Renal papilla |
| 4. Ureter               | 9. Renal medulla |
| 5. Renal capsule        | 10. Renal cortex |



**Figure 16.7** A plastic vascular cast of a kidney and ureter.

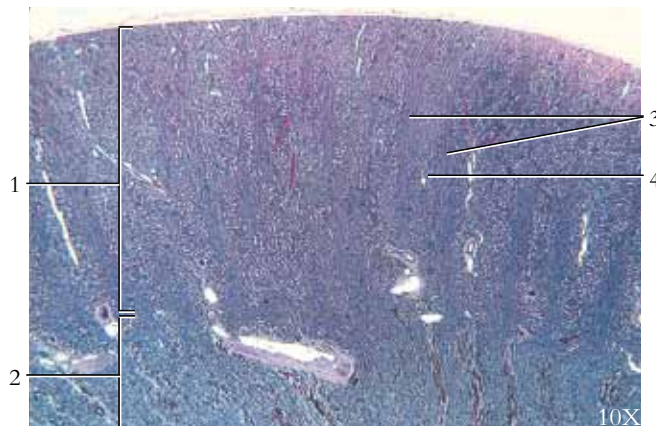
- |                      |                 |
|----------------------|-----------------|
| 1. Arteriole network | 4. Renal artery |
| 2. Major calyx       | 5. Ureter       |
| 3. Renal pelvis      |                 |





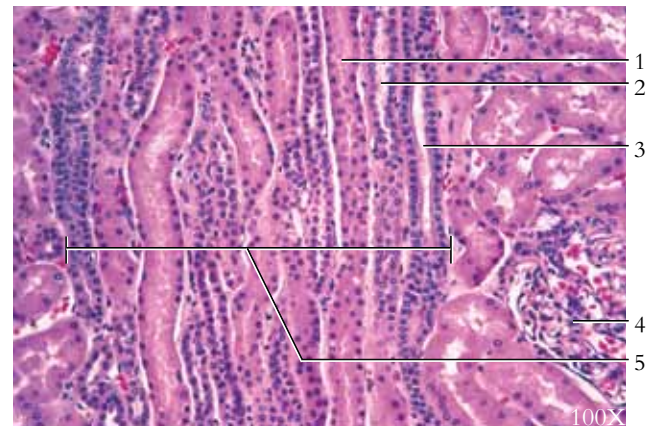
**Figure 16.8** A transaxial CT image of abdominal viscera. Note the large renal cyst in the right kidney.

1. Superior mesenteric artery
2. Pancreas
3. Inferior vena cava
4. Renal cyst
5. Body of lumbar vertebra
6. Right kidney
7. Vertebral foramen
8. Subcutaneous fat
9. Small intestine
10. Abdominal portion of aorta
11. Left ureter
12. Renal pelvis
13. Renal cortex
14. Rib
15. Skin



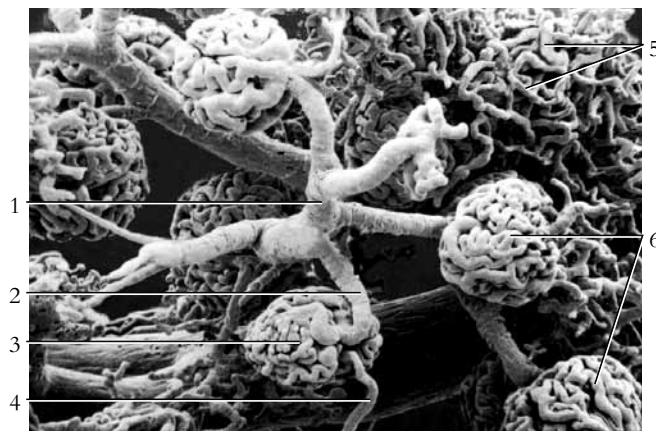
**Figure 16.9** Kidney.

1. Renal cortex
2. Renal medulla
3. Medullary rays
4. Cortical labyrinth



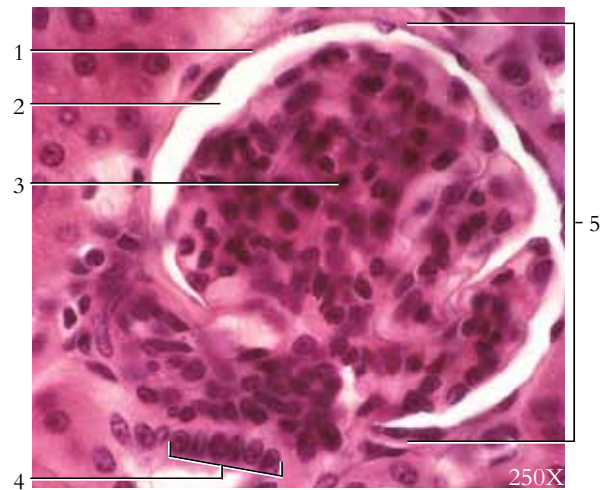
**Figure 16.10** Medullary ray.

1. Proximal tubule (of straight portion)
2. Distal tubule (of straight portion)
3. Collecting tubule
4. Glomerulus
5. Medullary ray



**Figure 16.11** An electron micrograph of the renal cortex.

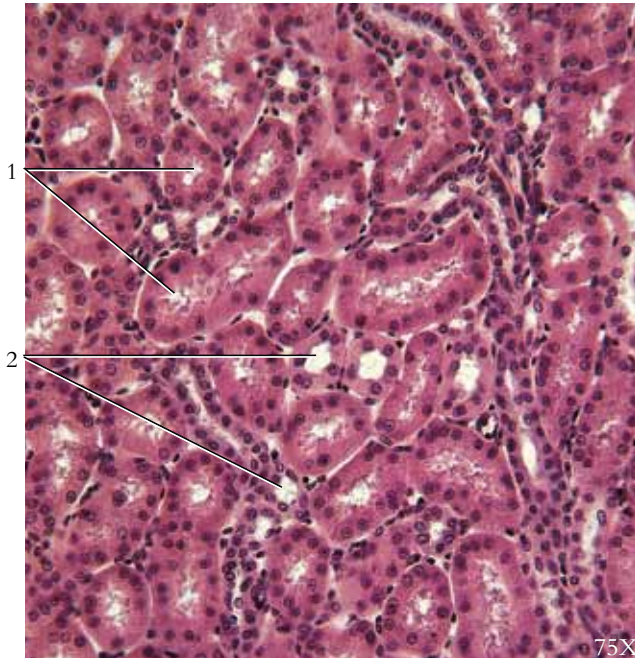
1. Interlobular artery
2. Afferent glomerular arteriole
3. Glomerulus
4. Efferent glomerular arteriole
5. Peritubular capillaries
6. Glomeruli



**Figure 16.12** Renal corpuscle.

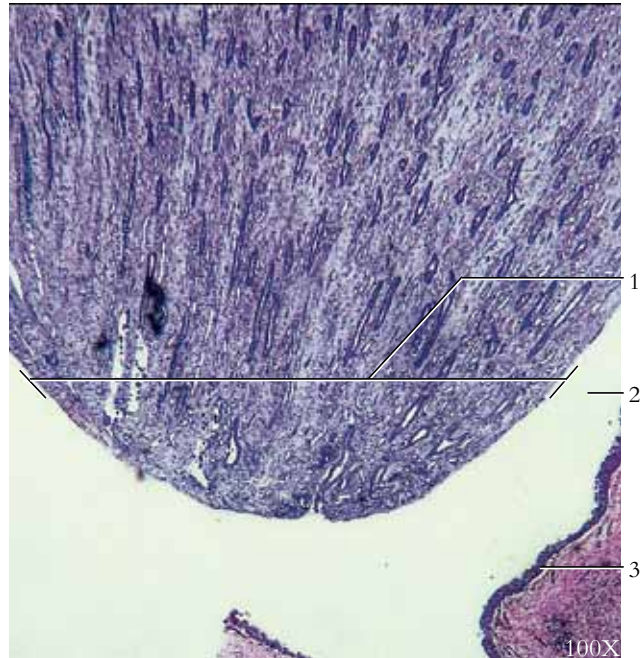
1. Glomerular capsule
2. Urinary space
3. Glomerulus
4. Macula densa of distal tubule
5. Renal corpuscle





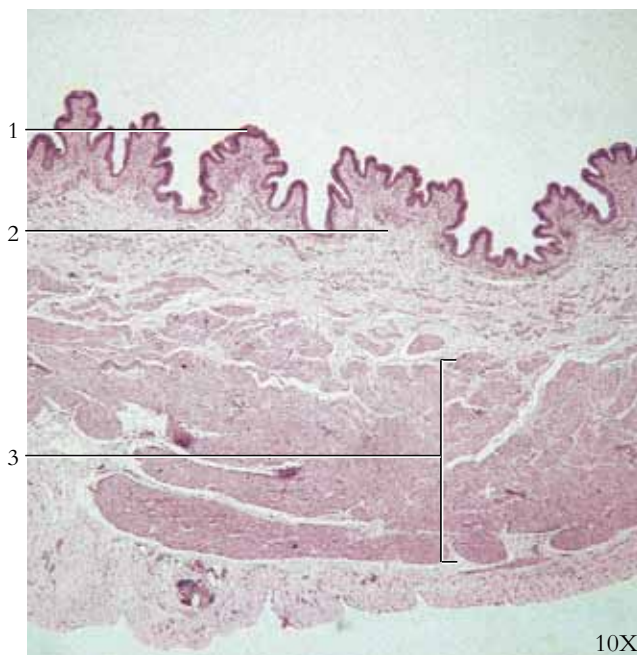
**Figure 16.13** Cortical labyrinth.

1. Proximal convoluted tubule
2. Distal convoluted tubule



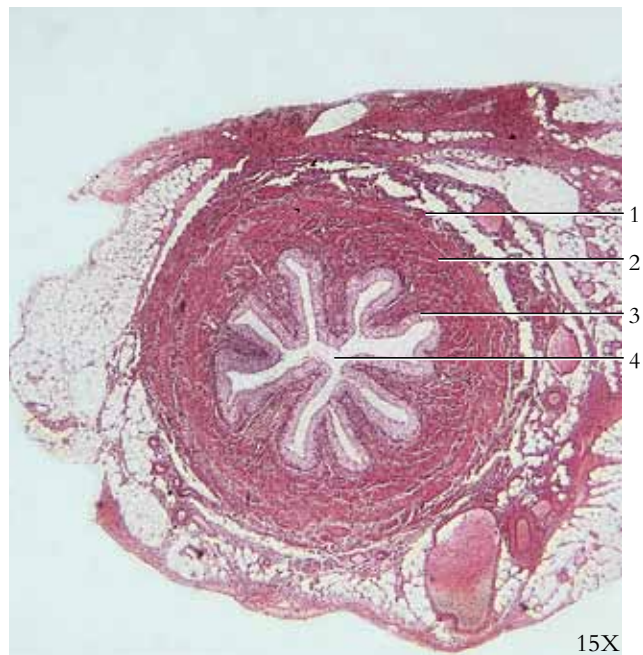
**Figure 16.14** Renal papilla.

1. Renal papilla
2. Minor calyx
3. Transitional epithelium



**Figure 16.15** Wall of urinary bladder.

1. Transitional epithelium
2. Lamina propria
3. Muscularis



**Figure 16.16** Ureter, as shown in cross section.

1. Adventitia
2. Muscularis
3. Mucosa
4. Lumen



**Figure 16.17** A pyelogram of the urinary system.

|                     |                        |
|---------------------|------------------------|
| 1. 12th rib         | 5. Renal pelvis        |
| 2. Major calyx      | 6. 3rd lumbar vertebra |
| 3. Ureter           | 7. Urinary bladder     |
| 4. Sacroiliac joint |                        |



**Figure 16.18** A radiograph showing a renal calculus (kidney stone) in the renal pelvis of the right kidney.

|                               |                    |
|-------------------------------|--------------------|
| 1. Renal calculus             | 4. Left ureter     |
| 2. Major calyx of left kidney | 5. Urinary bladder |
| 3. Renal pelvis of kidney     |                    |



**Figure 16.19** Renal calculi (stones) from the urinary bladders of two different patients. Renal calculi vary considerably in appearance and size and may develop in the renal pelvis of the kidney or in the urinary bladder.



# Chapter 17

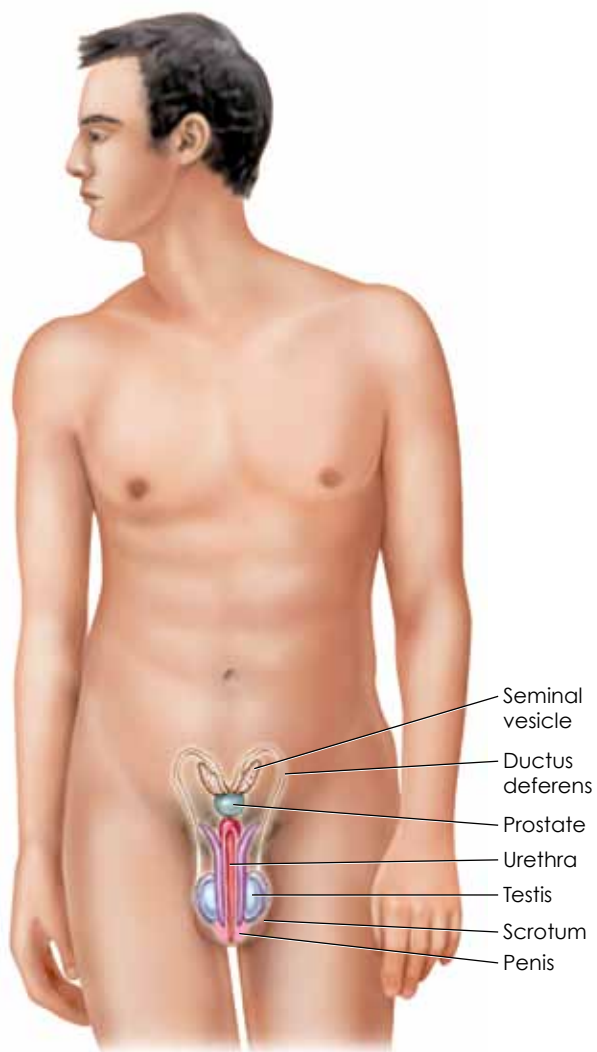
## Reproductive System

The organs of the male and female reproductive systems produce gametes and provide the mechanism for the union of these sex cells during the process of coitus (sexual intercourse). It is through sexual reproduction that individuals of a species are propagated, each having a genetic diversity inherited from both parents.

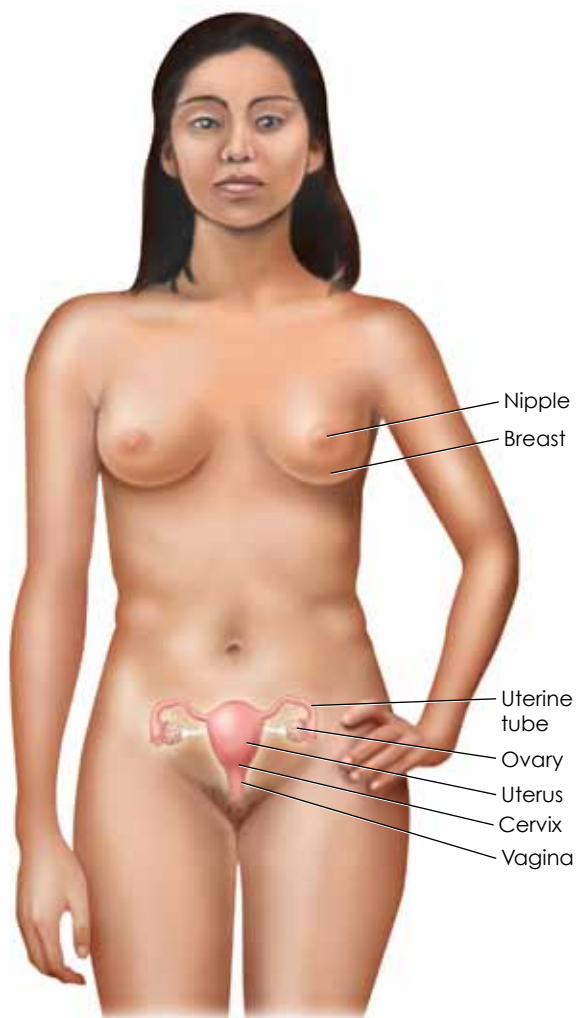
The male reproductive system consists of the **testes** (in the **scrotum**), excretory glands (**seminal vesicles**, **prostate**, and **bulbourethral glands**), and **penis**. The functions of the male

reproductive system are to secrete sex hormones, produce spermatozoa, and ejaculate semen (spermatozoa and additives) into the vagina of the female.

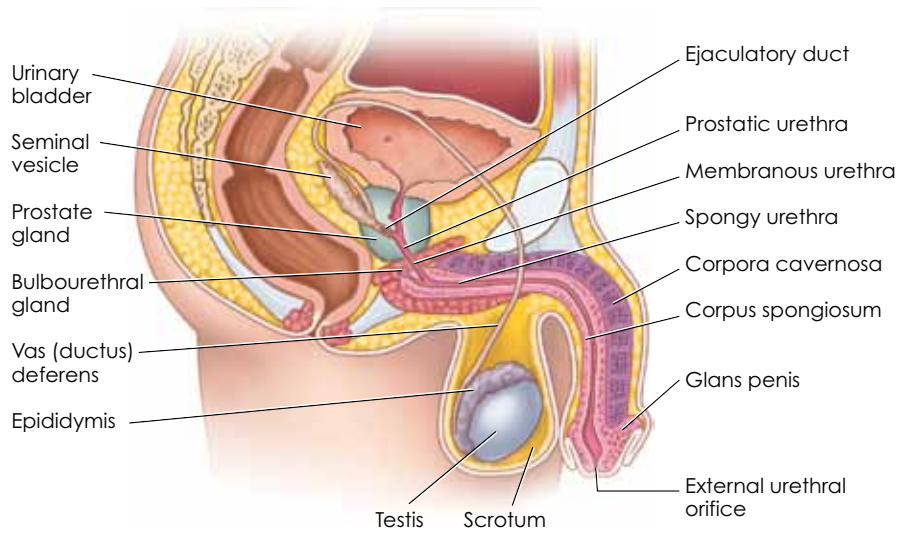
The female reproductive system consists of the **ovaries**, **uterus**, **uterine tubes**, **vagina**, **external genitalia**, and **mammary glands**. The functions of the female reproductive system are to secrete sex hormones, produce ova, receive ejaculated semen from the erect penis of the male, nourish the developing embryo and fetus, deliver the baby, and nurse the infant once it is born.



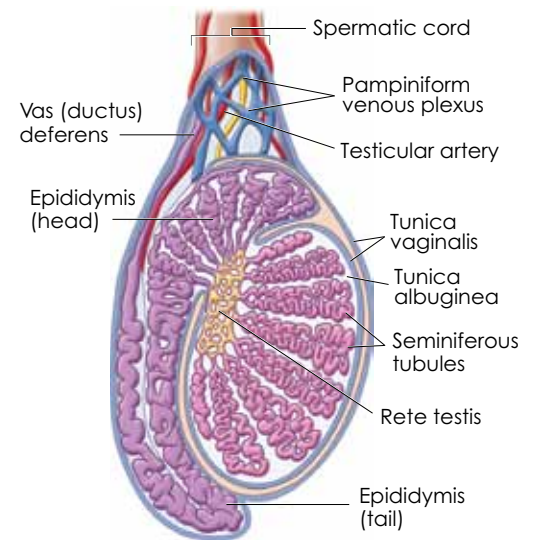
**Figure 17.1** The organs of the male reproductive system.



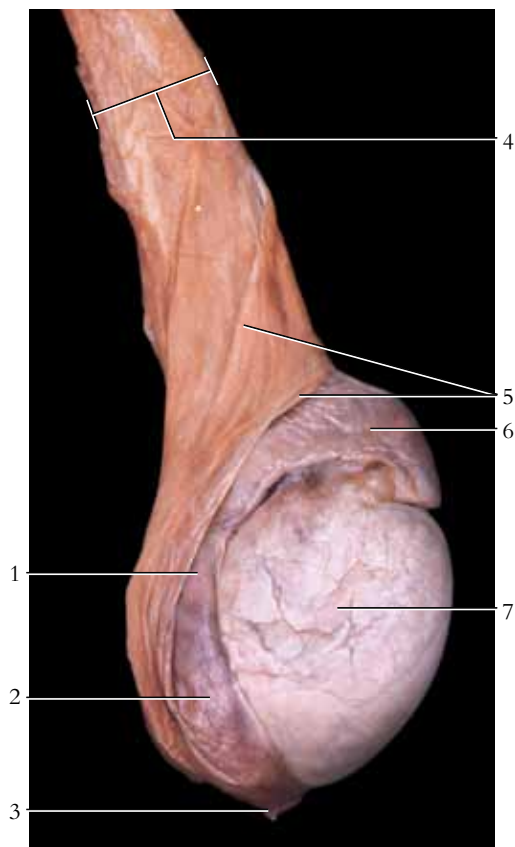
**Figure 17.2** The organs of the female reproductive system.



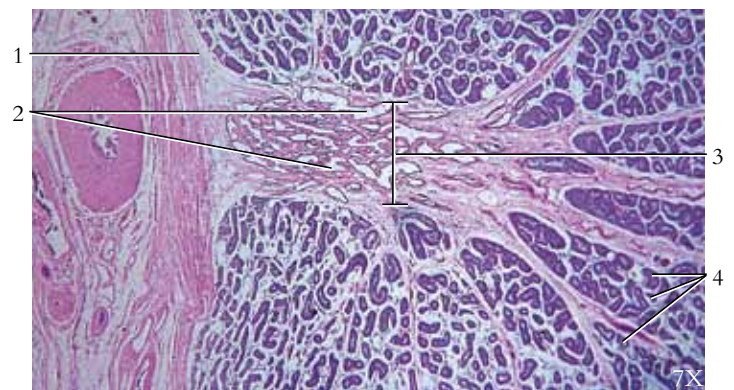
**Figure 17.3** The structure of the male genitalia.



**Figure 17.4** The structure of the testis.



**Figure 17.5** A testis and associated structures.  
 1. Body of epididymis 5. Spermatic fascia  
 2. Tail of epididymis 6. Head of epididymis  
 3. Gubernaculum 7. Testis  
 4. Spermatic cord

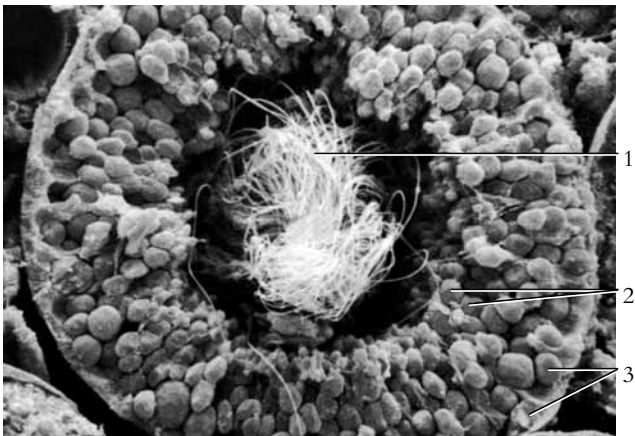


**Figure 17.6** Testis.  
 1. Tunic albuginea 3. Mediastinum  
 2. Tubules of rete testis 4. Seminiferous tubules



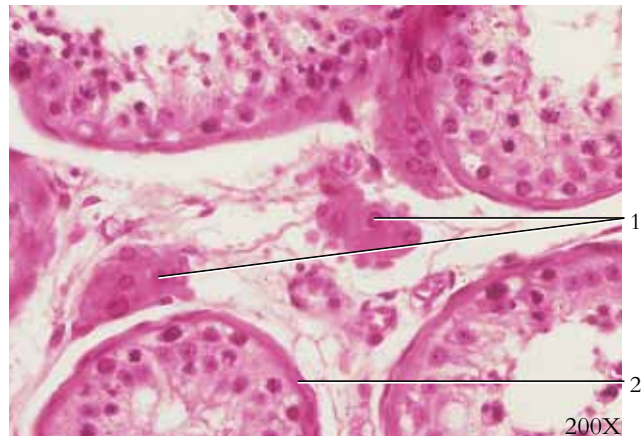
**Figure 17.7** A cancerous testis; orchiectomy is the removal of a testis.





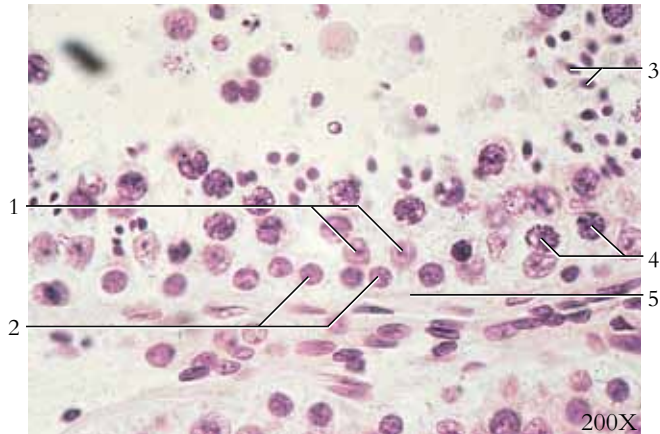
**Figure 17.8** An electron micrograph of a seminiferous tubule.

1. Spermatozoa
2. Spermatids
3. Spermatogonia



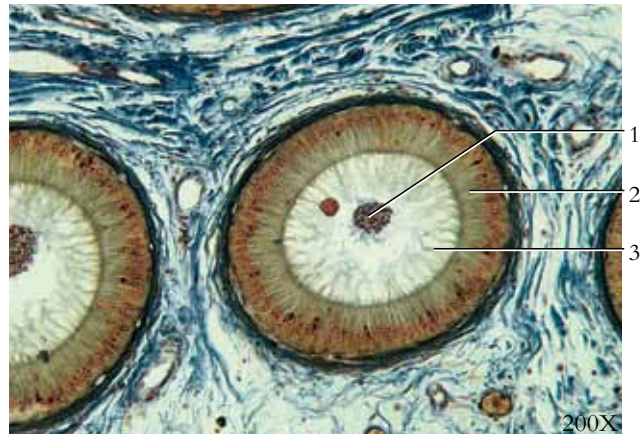
**Figure 17.9** Testis.

1. Interstitial (Leydig) cells
2. Seminiferous tubule



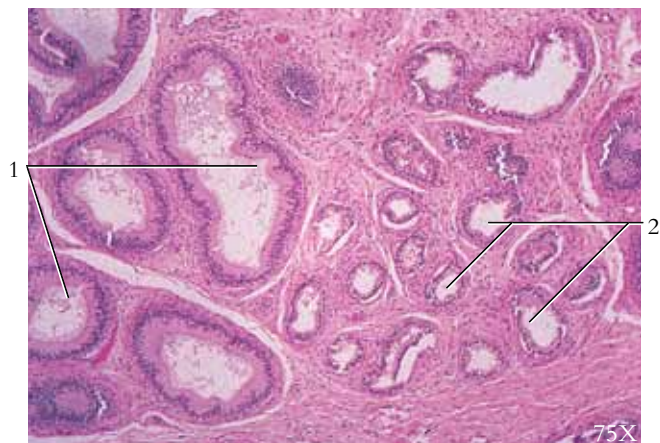
**Figure 17.10** Wall of seminiferous tubule.

1. Sustentacular (Sertoli) cells
2. Spermatogonia
3. Spermatids
4. Primary spermatocytes
5. Boundary of seminiferous tubule



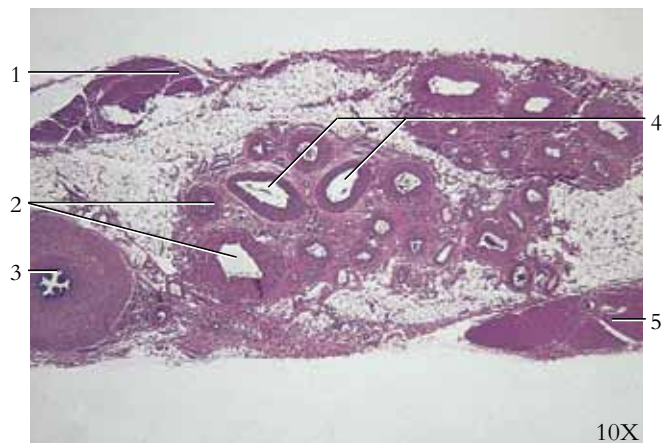
**Figure 17.11** Epididymis.

1. Sperm in lumen
2. Pseudostratified columnar epithelium
3. Stereocilia



**Figure 17.12** Efferent ductules.

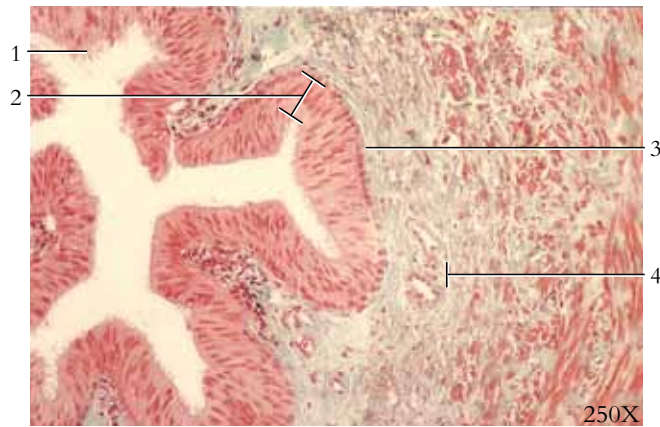
1. Duct of epididymis
2. Efferent ductules



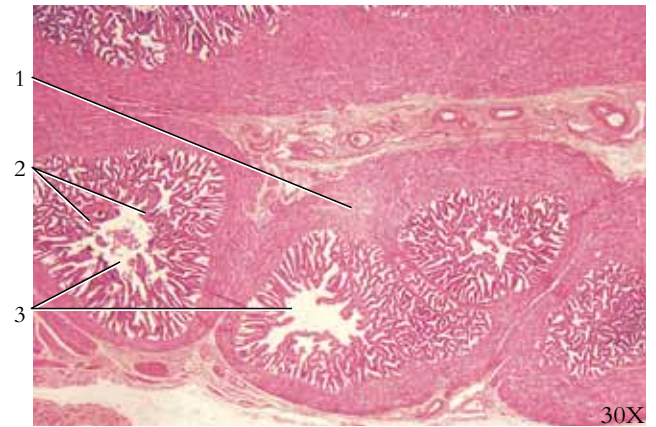
**Figure 17.13** Spermatic cord.

1. Cremaster muscle
2. Veins of the pampiniform plexus
3. Ductus deferens
4. Testicular arterioles
5. Cremaster muscle

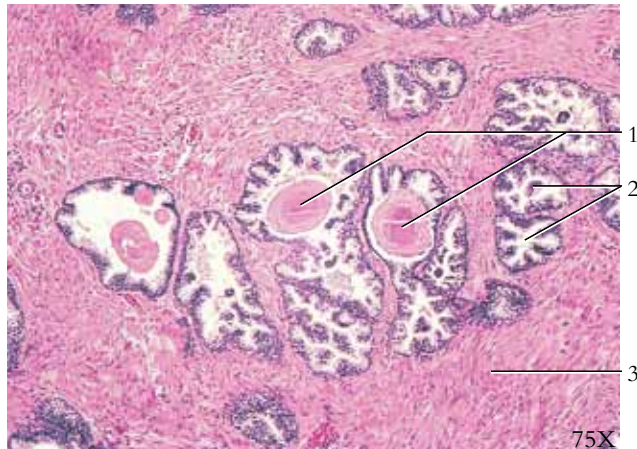


**Figure 17.14** Ductus deferens.

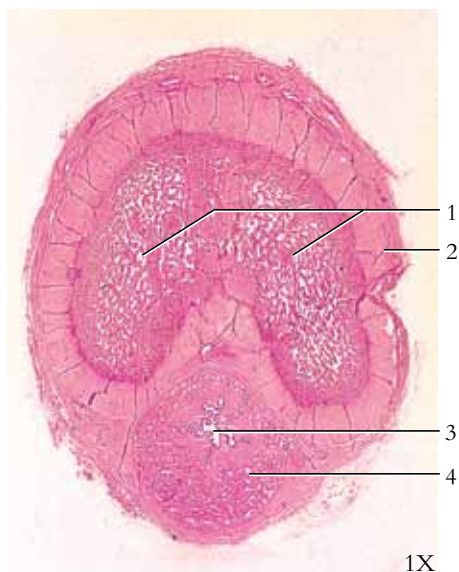
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|---|-------------------|
| 1. Stereocilia                          | 3. Lamina propria |
| 2. Pseudostratified columnar epithelium | 4. Muscularis     |

**Figure 17.15** Seminal vesicle.

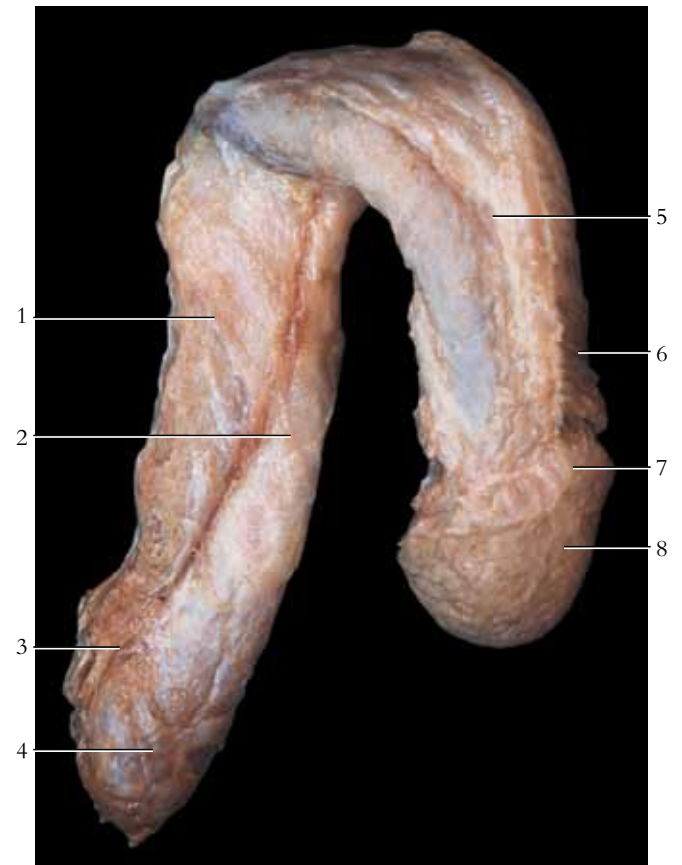
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|-------------------------|----------|
| 1. Fibromuscular stroma | 3. Lumen |
| 2. Mucosal folds        |          |

**Figure 17.16** Prostate.

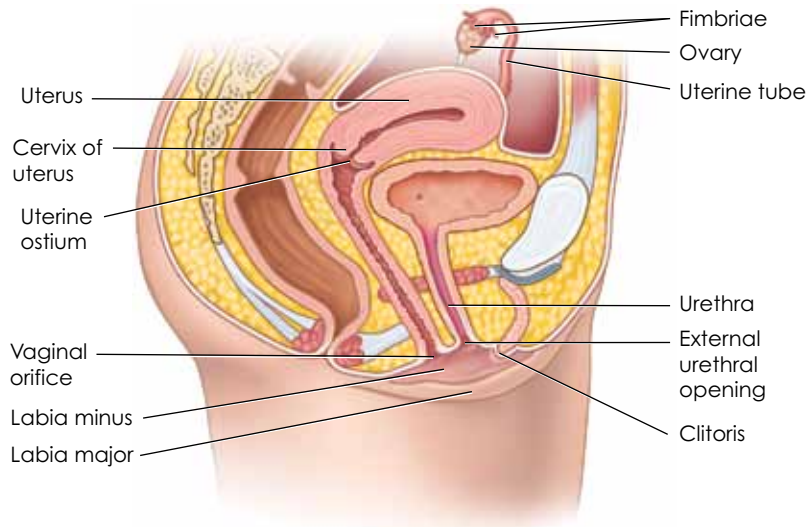
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|-------------------------|
| 1. Prostate concretions |
| 2. Glandular acini      |
| 3. Fibromuscular stroma |

**Figure 17.17** Penis.

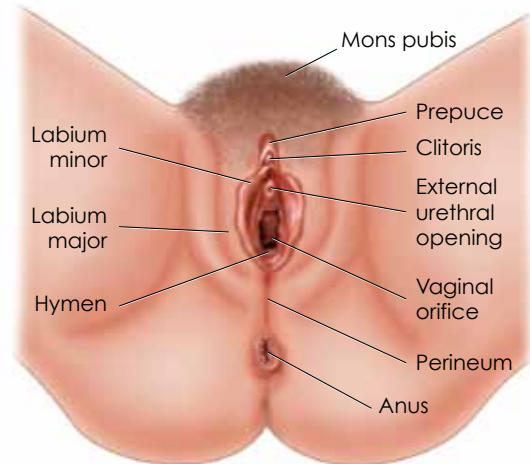
- |                      |
|----------------------|
| 1. Corpora cavernosa |
| 2. Tunica albuginea  |
| 3. Urethra           |
| 4. Corpus spongiosum |

**Figure 17.18** The structure of the penis.

- |                      |                   |
|----------------------|-------------------|
| 1. Corpora cavernosa | 5. Body of penis  |
| 2. Corpus spongiosum | 6. Skin of penis  |
| 3. Crus of penis     | 7. Corona glandis |
| 4. Bulb of penis     | 8. Glans penis    |



**Figure 17.19** The external genitalia and internal reproductive organs of the female reproductive system.



**Figure 17.20** The external genitalia of the female.



**Figure 17.21** The external genitalia and vagina.

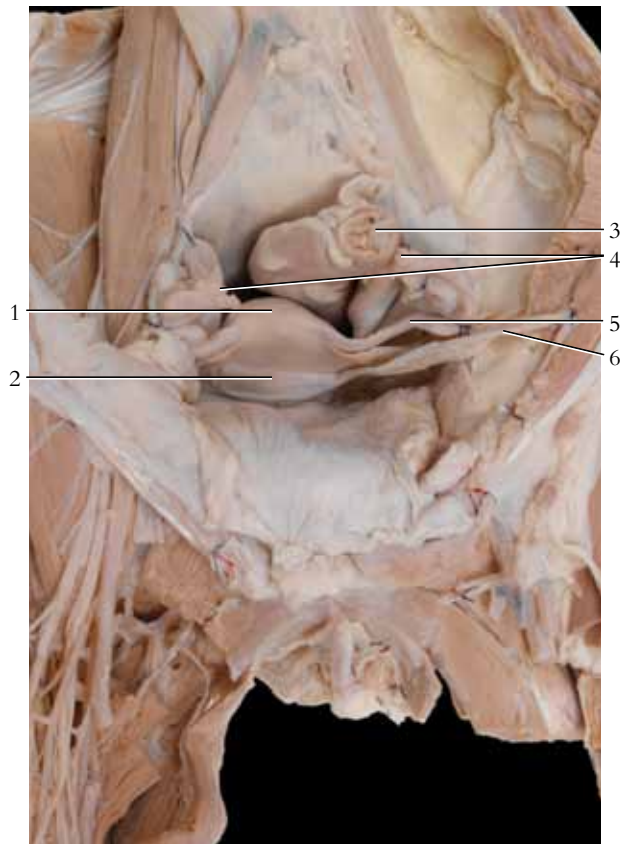
1. Mons pubis
2. Clitoris
3. Labium minor
4. Urethral opening
5. Labium major
6. Vagina (dissected open)
7. Fornix
8. Uterine ostium
9. Cervix of uterus



**Figure 17.22** Vagina.

1. Nonkeratinized stratified squamous epithelium
2. Lamina propria





**Figure 17.23** The uterus within the pelvic cavity.

- |                        |                        |
|------------------------|------------------------|
| 1. Fundus of uterus    | 4. Fimbriae            |
| 2. Body of uterus      | 5. Uterine tube        |
| 3. Sigmoid colon (cut) | 6. Suspensory ligament |



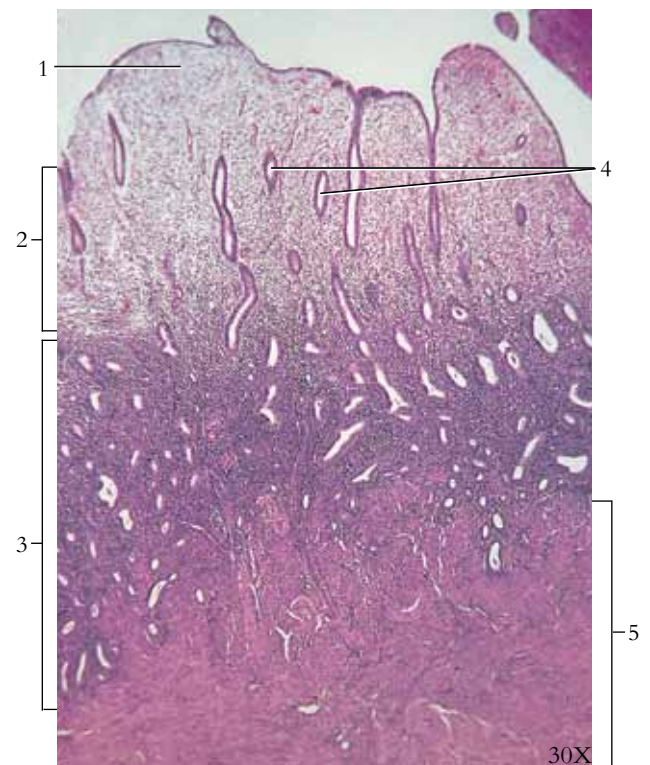
**Figure 17.25** Ampulla of uterine tube.

- |                  |               |
|------------------|---------------|
| 1. Lumen         | 3. Muscularis |
| 2. Mucosal folds | 4. Serosa     |



**Figure 17.24** A posterior view of the uterus and uterine tubes.

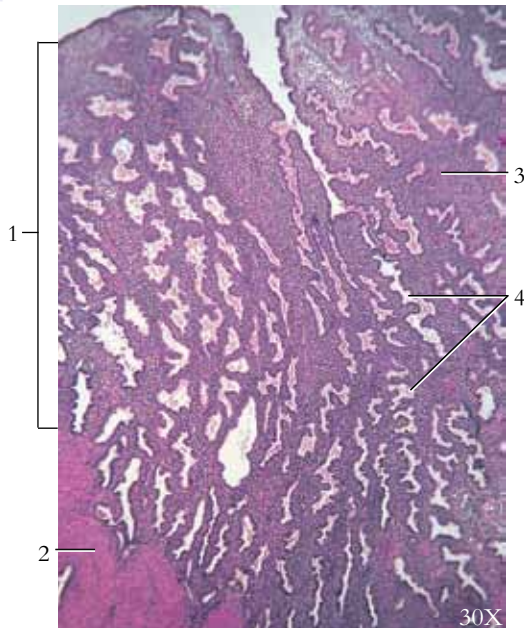
- |                     |                     |
|---------------------|---------------------|
| 1. Uterine tube     | 4. Body of uterus   |
| 2. Fimbriae         | 5. Cervix of uterus |
| 3. Fundus of uterus |                     |



**Figure 17.26** Uterus: proliferative phase.

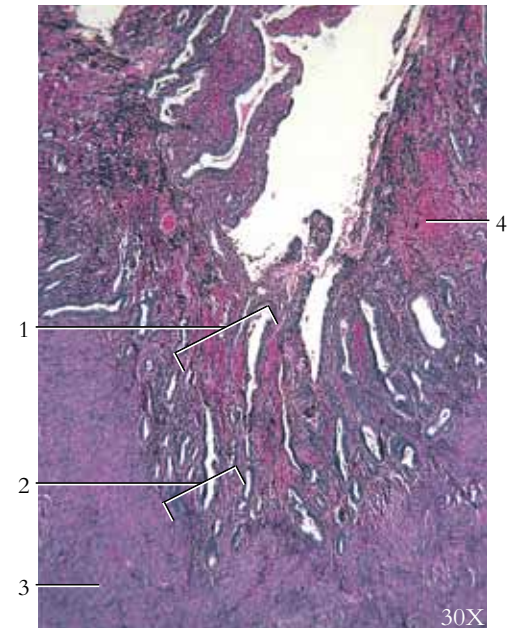
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|--------------------------------------|-------------------------------|
| 1. Endometrial stroma                | 4. Endometrial uterine glands |
| 2. Lamina functionalis (endometrium) | 5. Myometrium                 |
| 3. Lamina basalis (endometrium)      |                               |





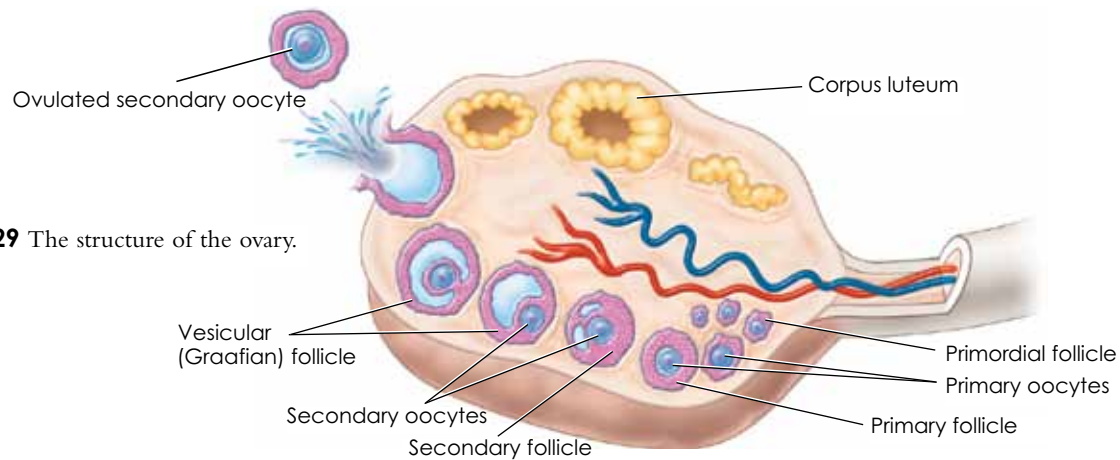
**Figure 17.27** Uterus: secretory phase.

- |                       |                               |
|-----------------------|-------------------------------|
| 1. Endometrium        | 4. Endometrial uterine glands |
| 2. Myometrium         |                               |
| 3. Endometrial stroma |                               |

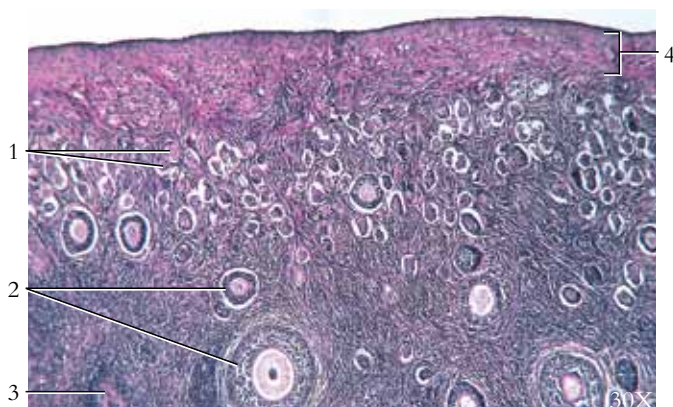


**Figure 17.28** Uterus: menstrual phase.

- |                                       |                    |
|---------------------------------------|--------------------|
| 1. Disintegrating lamina functionalis | 3. Myometrium      |
| 2. Lamina basalis (still intact)      | 4. Blood in stroma |



**Figure 17.29** The structure of the ovary.



**Figure 17.30** Ovary.

- |                         |                     |
|-------------------------|---------------------|
| 1. Primordial follicles | 3. Atretic follicle |
| 2. Primary follicles    | 4. Tunica albuginea |

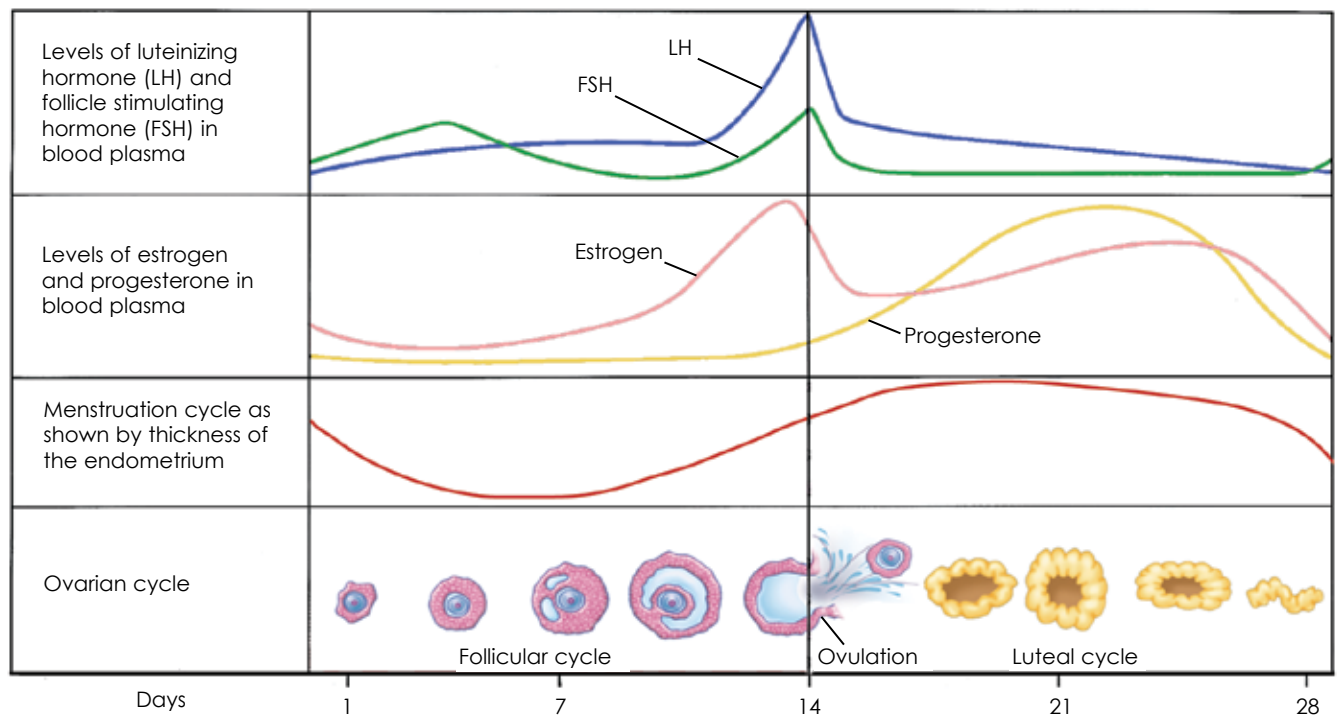


**Figure 17.31** Secondary follicle.

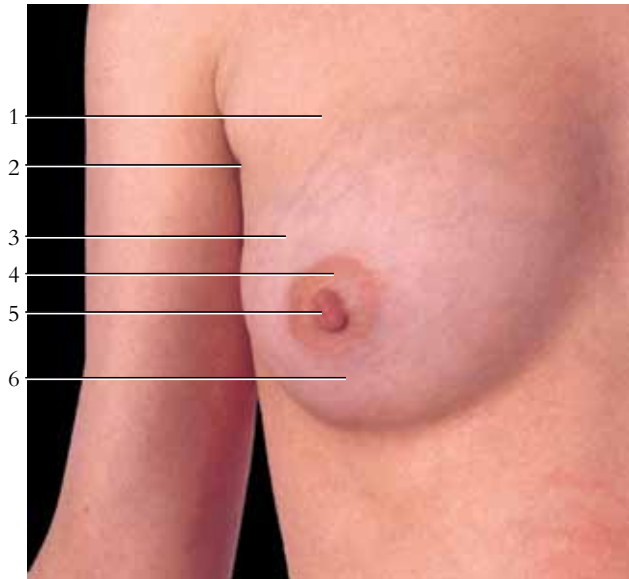
- |                    |                  |
|--------------------|------------------|
| 1. Granulosa cells | 4. Oocyte        |
| 2. Antrum          | 5. Theca interna |
| 3. Zona pellucida  | 6. Theca externa |

**Figure 17.32** Corpus luteum.

1. Corpus luteum
2. Wall of corpus luteum
3. Former follicular antrum

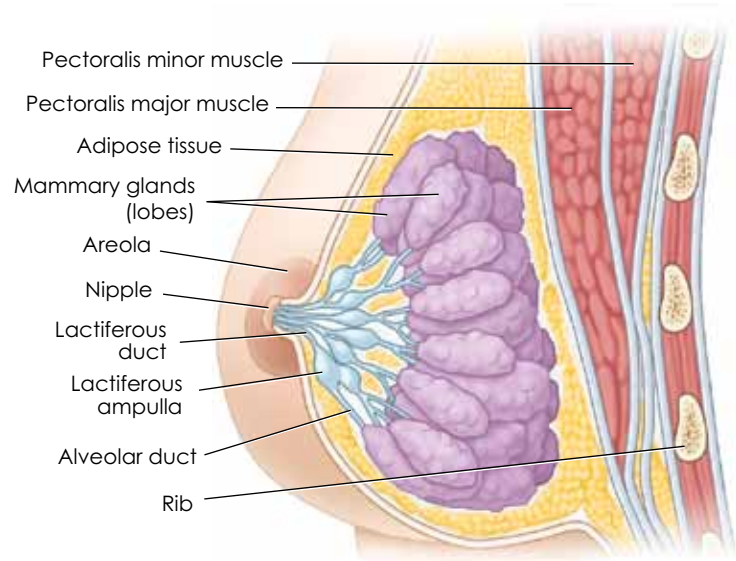
**Figure 17.33** A human ovary showing ovarian cysts.**Figure 17.34** The female ovarian and menstruation cycle.



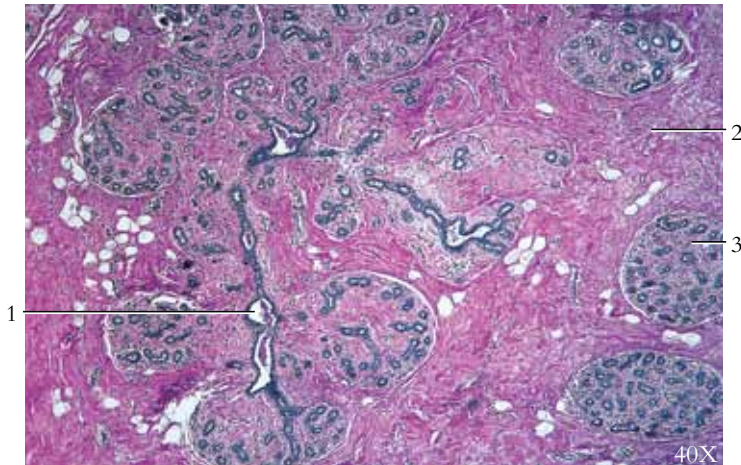


**Figure 17.35** The surface anatomy of the female breast.

1. Pectoralis major muscle
2. Axilla
3. Lateral process of breast
4. Areola
5. Nipple
6. Breast (containing mammary glands)

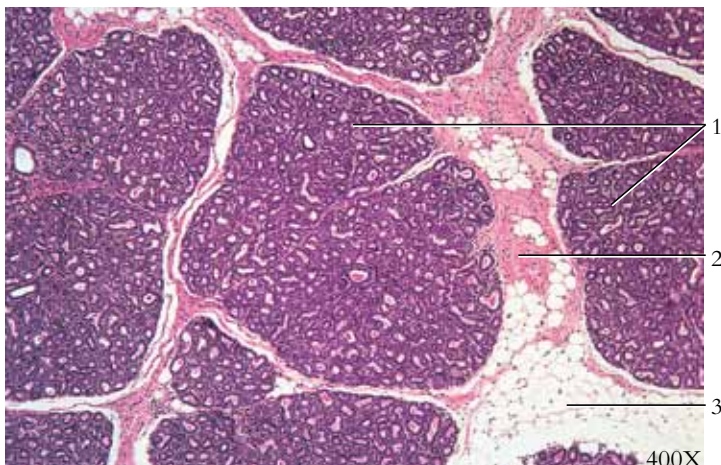


**Figure 17.36** The mammary gland.



**Figure 17.37** Mammary glands, (non-lactating glands).

1. Interlobular duct
2. Interlobular connective tissue
3. Lobule of glandular tissue



**Figure 17.38** Mammary glands, (lactating glands).

1. Lobules of glandular tissue
2. Intralobular connective tissue
3. Adipose cells

# Chapter 18

## Developmental Biology

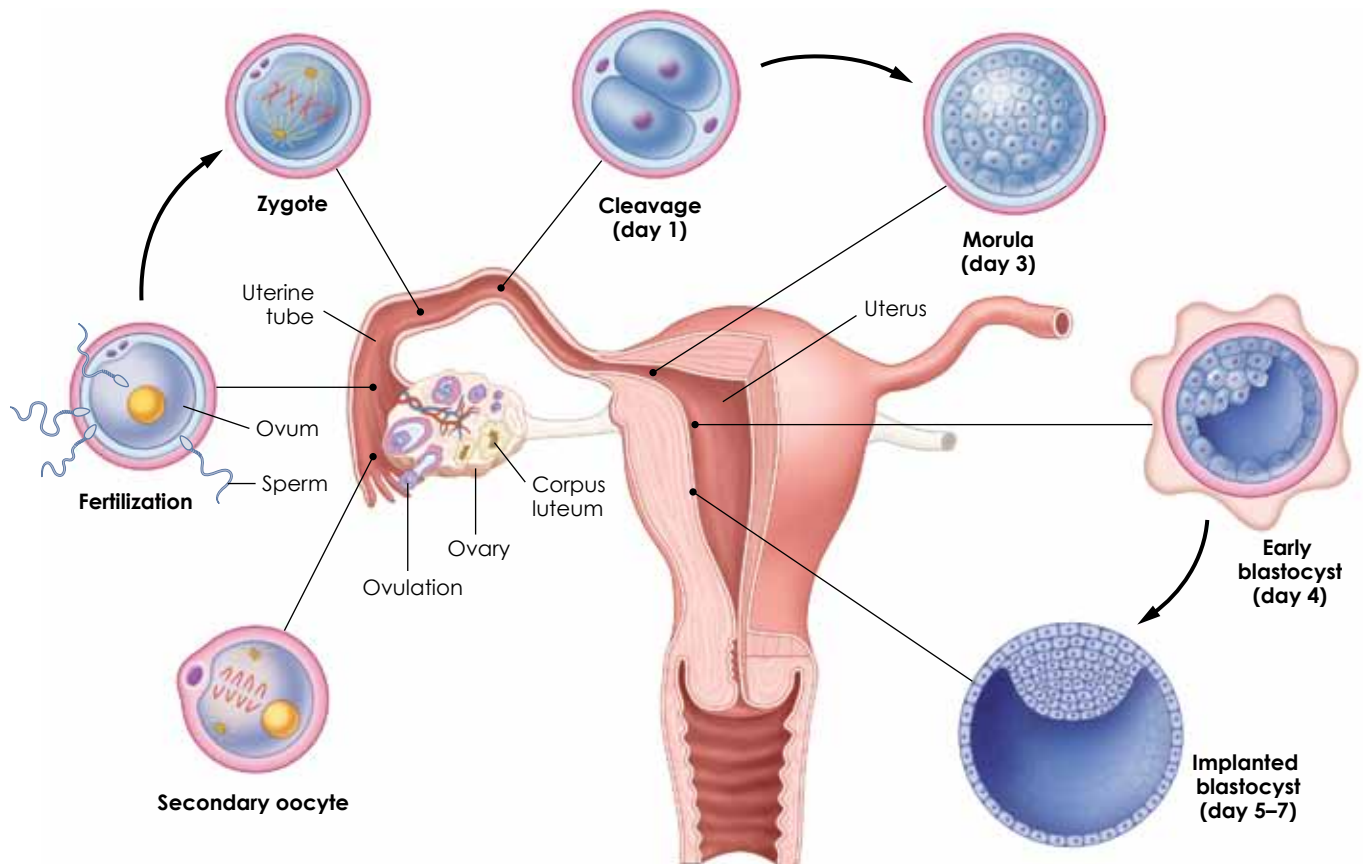
The period of human pregnancy, which generally requires 38 weeks, is known as **gestation**. **Morphogenesis** is the sequence of changes that occur in the formation of the baby's body structures. Although gestation is frequently discussed chronologically as trimesters, prenatal development is more accurately divided morphogenically into three periods based on structural changes. On this basis, the **pre-embryonic period** includes the first two weeks following fertilization, the **embryonic period** includes the following six weeks, and the **fetal period** includes the final 30 weeks.

The events of the two-week pre-embryonic period include transportation of the fertilized egg, or **zygote**, through the uterine tube, mitotic divisions, implantation, and the formation of primordial embryonic tissue (fig. 18.1). Implantation begins between the fifth and seventh day and is made possible by the secretion of enzymes that digest a portion of the endometrium

of the uterus. During implantation, the **trophoblast cells** secrete **human chorionic gonadotropin (hCG)**, which prevents the breakdown of the endometrium and menstruation. The trophoblast cells also participate in the formation of the placenta.

The events of the six-week embryonic period include the differentiation of the germ layers into specific body organs and the formation of the extraembryonic membranes, including the **placenta**, **umbilical cord**, **amnion**, **yolk sac**, **allantois**, and **chorion**.

A small amount of tissue differentiation and organ development occurs during the fetal period, but for the most part fetal development is primarily limited to body growth. Labor and parturition (childbirth) are the culmination of gestation and require the action of **oxytocin** from the mother's pituitary gland, and **prostaglandins**, produced in her uterus.

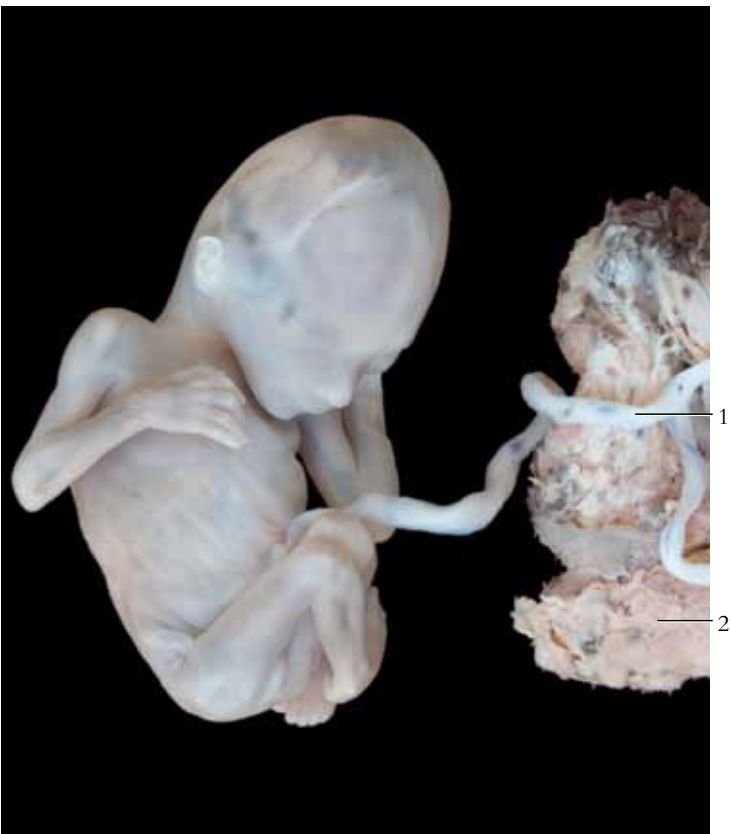


**Figure 18.1** The events of ovulation, fertilization, and implantation.



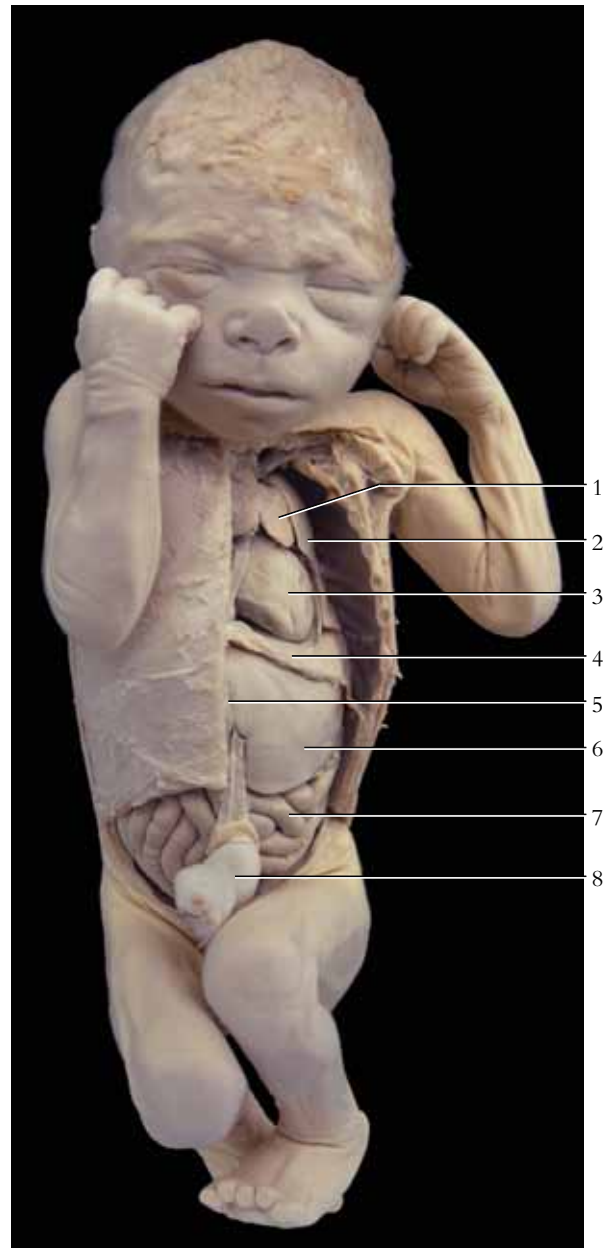


**Figure 18.2** A 8.1 week intrauterine pregnancy. Marks are indicated on the image to denote the crown and rump. The crown-rump length of this embryo is 18 mm. Ultrasonography, produced by a mechanical vibration of high frequency, produces a safe, high resolution of fetal structure. Most ultrasound scans are obtained on fetuses older than 12 weeks.



**Figure 18.3** A human fetus at approximately 18 weeks.

1. Umbilical cord
2. Placenta



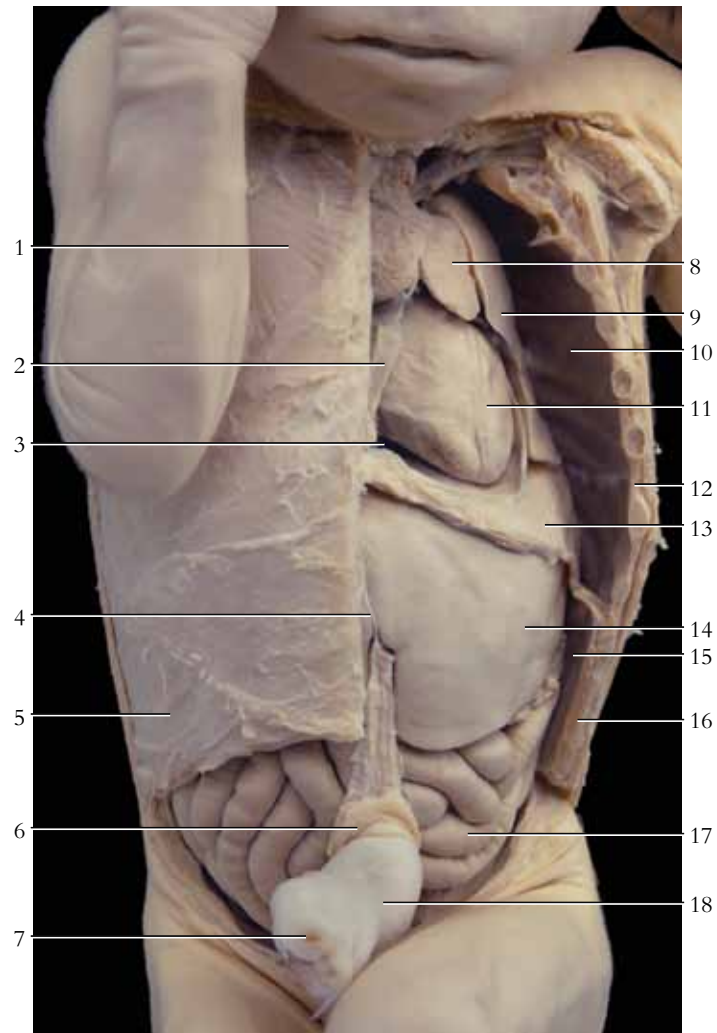
**Figure 18.4** A human fetus at approximately 28 weeks.

1. Thymus
2. Lung
3. Heart
4. Diaphragm
5. Falciform ligament
6. Liver
7. Small intestine
8. Umbilical cord



**Figure 18.5** The thoracic and abdominal viscera of a human fetus at approximately 28 weeks.

1. Pectoralis major m.
2. Pericardium (cut)
3. Pericardial cavity
4. Falciform ligament
5. External abdominal oblique m.
6. Umbilicus
7. Umbilical vein
8. Thymus
9. Lung
10. Pleural cavity
11. Heart
12. Thoracic wall
13. Diaphragm
14. Liver
15. Peritoneal cavity
16. Abdominal wall
17. Small intestine
18. Umbilical cord

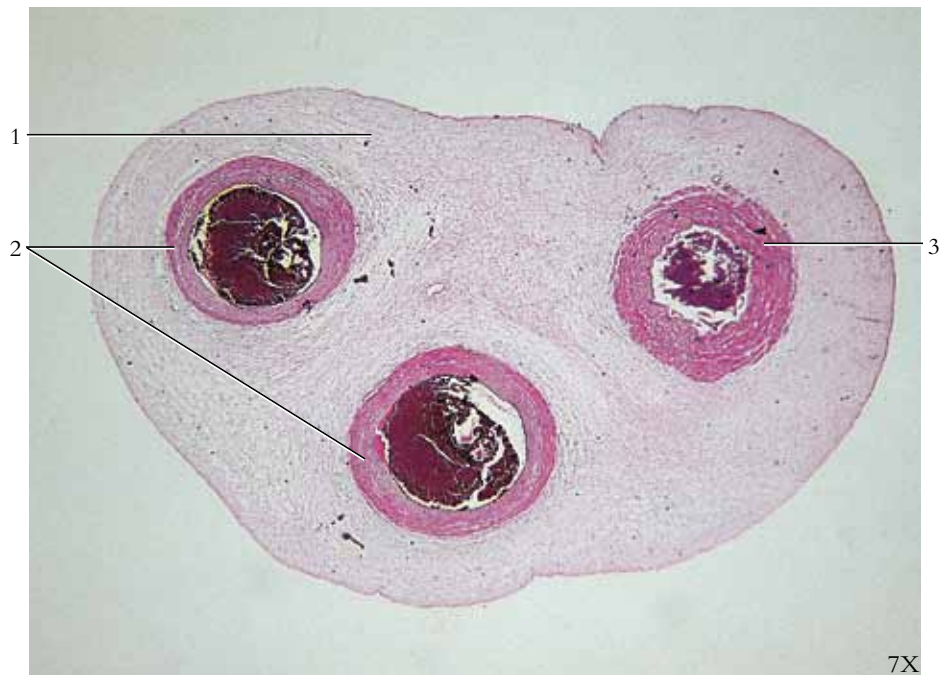


**Figure 18.6** Parturition, or childbirth.



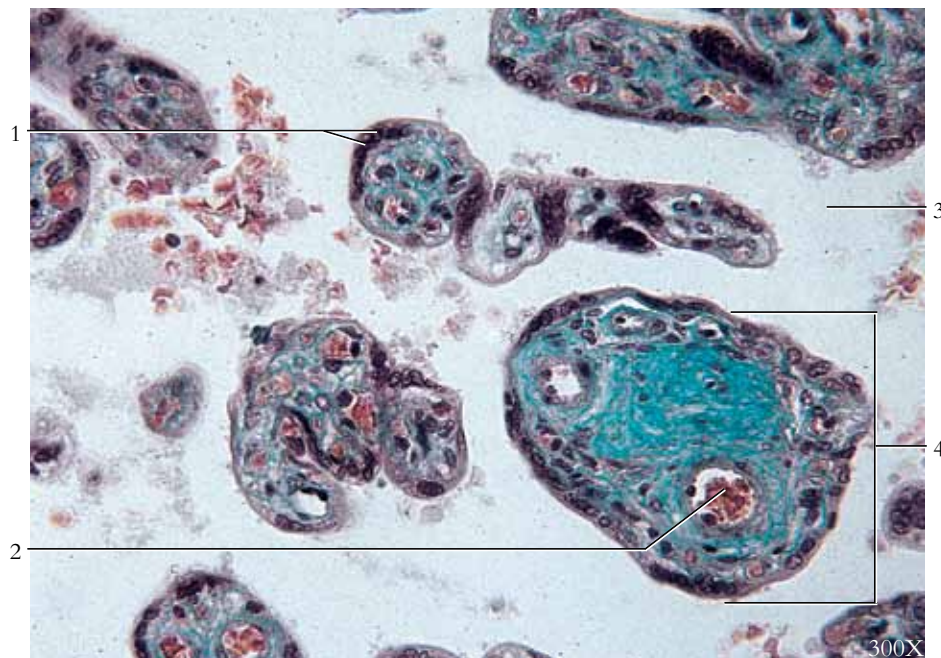
**Figure 18.7** Nursing.





**Figure 18.8** Umbilical cord.

1. Mucus connective tissue (Wharton's jelly)
2. Umbilical arteries
3. Umbilical vein



**Figure 18.9** Placenta.

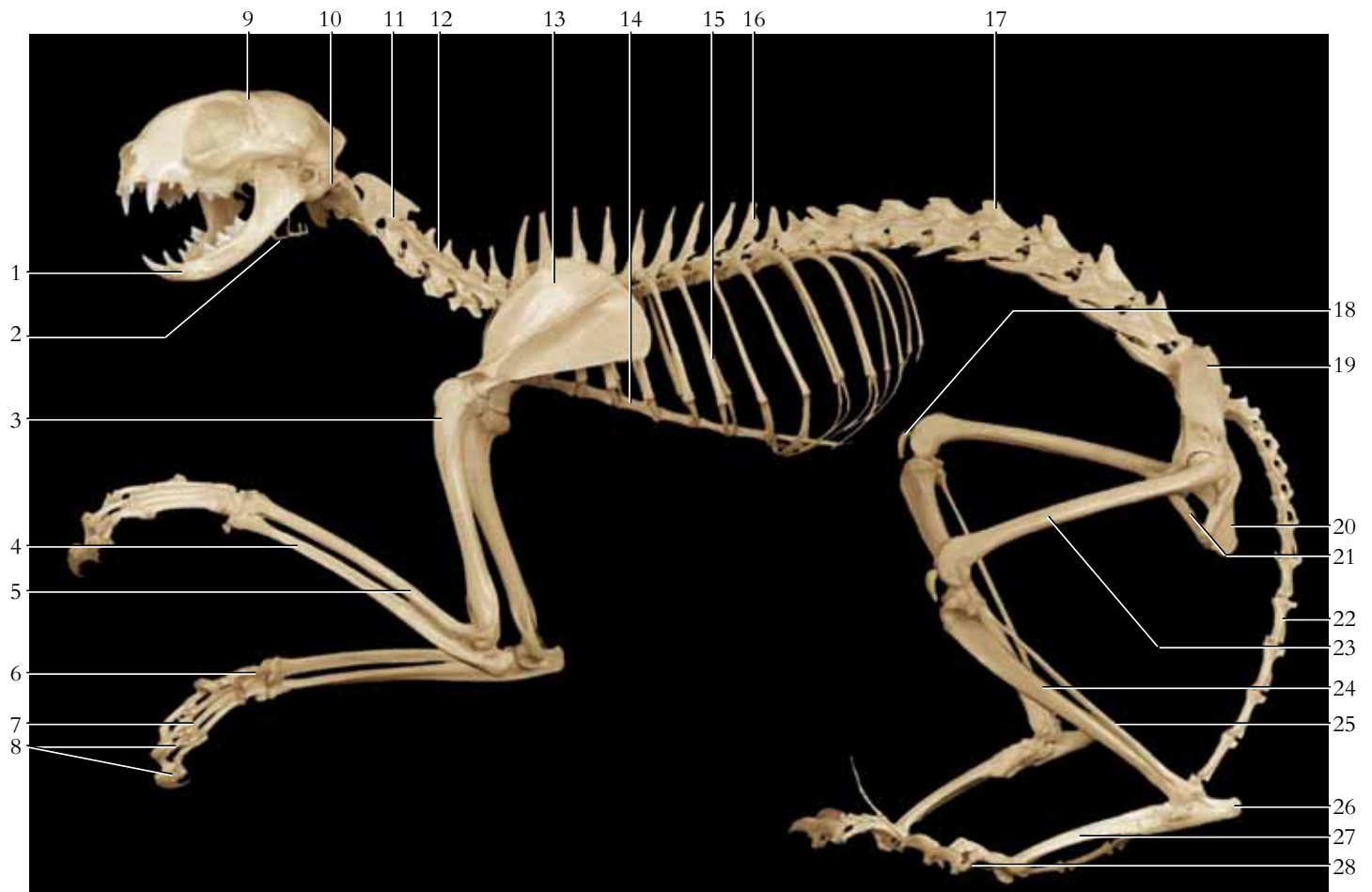
1. Nuclei of syncytiotrophoblast
2. Blood vessel containing fetal blood cells
3. Intervillous space containing maternal blood cells
4. Chorionic villus

# Chapter 19

## Cat Dissection

Embalmed cats purchased from biological supply houses are excellent specimens for dissecting and learning basic mammalian anatomy. Before the muscles and viscera of a cat can be studied, the specimen's skin has to be removed according to the following suggested guidelines.

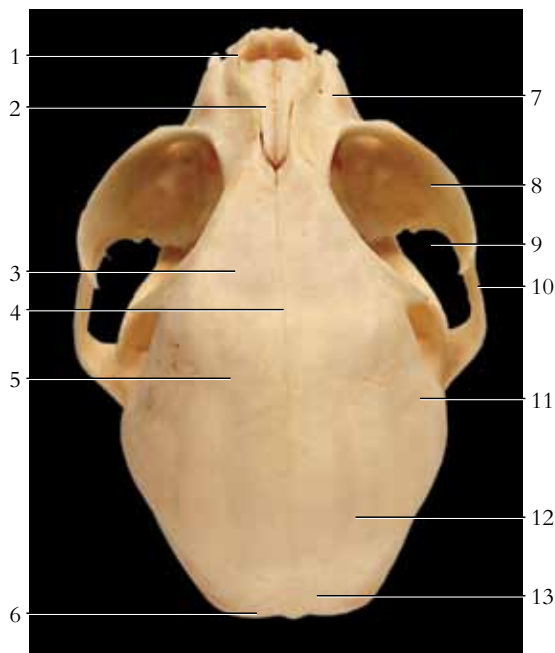
1. Place the cat on a dissecting tray dorsal side up. Using a sharp scalpel, make a short, shallow incision through the skin across the nape of the neck. With your scissors, continue a dorsal midline incision forward over the skull and down the back to about two inches onto the tail. Sever the tail with bone shears or a saw and discard.
2. Make a shallow incision around the neck and down each foreleg to the paws. Continue a circular incision around each wrist. Beginning at the base of the tail, make incisions down each of the hind legs to the ankles. Make a circular cut around each ankle.
3. Carefully remove the skin, using your fingers or a blunt probe to separate the skin from underlying connective tissue. Where it is necessary to use a scalpel, keep the cutting edge directed toward the skin away from the muscle. If your specimen is a male, make an incision around the genitalia, leaving the skin intact. If your specimen is a female, the mammary glands will appear as longitudinal, glandular masses along the ventral side of the abdomen and thorax. They should be removed with the skin.
4. After the specimen is skinned, remove the excess fat and connective tissue to expose the underlying muscles. Make certain that the muscles are separated along their natural boundaries. If a transection of a muscle is necessary, isolate the muscle from its attached connective tissue and make a clean cut across the belly of the muscle, leaving the origin and insertion intact.
5. At the end of the laboratory period, wrap your specimen in muslin cloth and store it in a tight, heavy-duty plastic bag. Wet your specimen from time to time with a preservative solution (usually 2%-3% phenol). Caution needs to be taken when using a phenol wetting solution as it is caustic and poisonous if misused or used in a concentrated form.



**Figure 19.1** The cat skeleton.

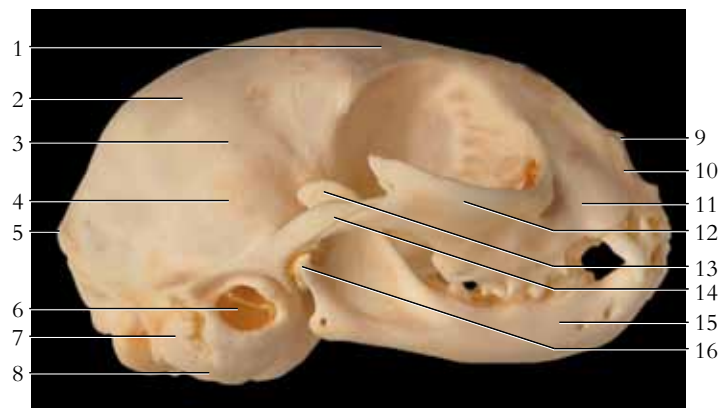
- |               |                     |                       |                       |                     |                      |
|---------------|---------------------|-----------------------|-----------------------|---------------------|----------------------|
| 1. Mandible   | 6. Carpal bones     | 11. Axis              | 16. Thoracic vertebra | 21. Pubis           | 26. Tarsal bones     |
| 2. Hyoid bone | 7. Metacarpal bones | 12. Cervical vertebra | 17. Lumbar vertebra   | 22. Caudal vertebra | 27. Metatarsal bones |
| 3. Humerus    | 8. Phalanges        | 13. Scapula           | 18. Patella           | 23. Femur           | 28. Phalanges        |
| 4. Ulna       | 9. Skull            | 14. Sternum           | 19. Ilium             | 24. Tibia           |                      |
| 5. Radius     | 10. Atlas           | 15. Rib               | 20. Ischium           | 25. Fibula          |                      |





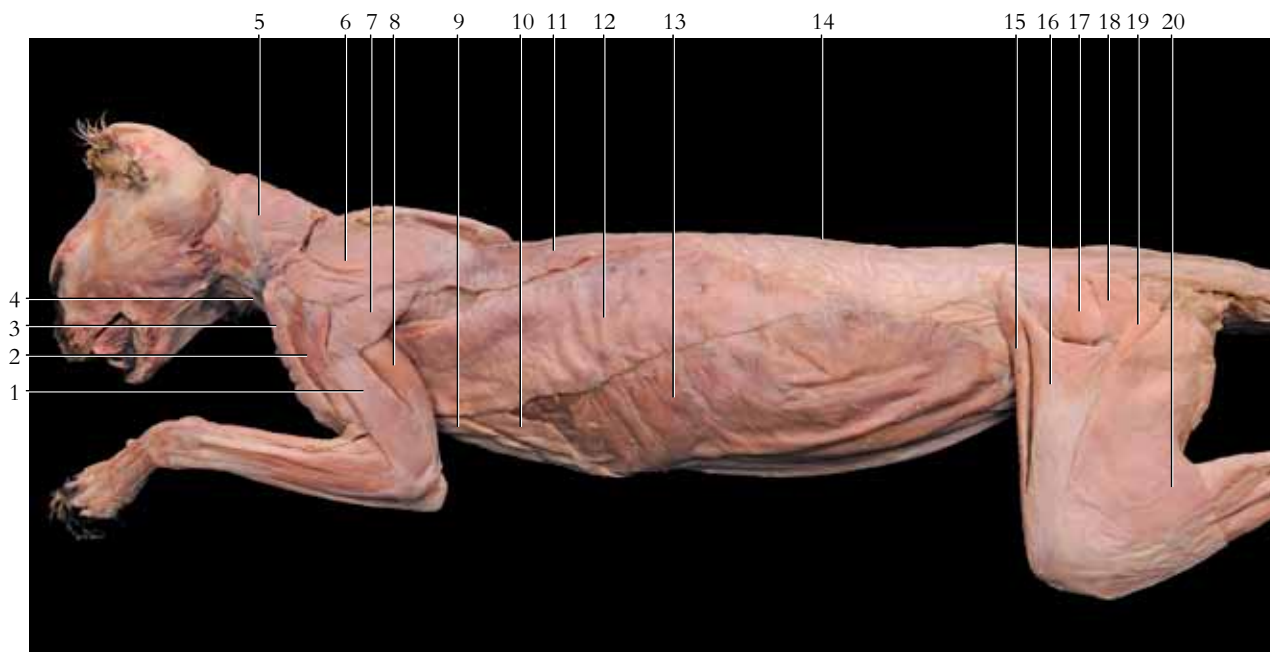
**Figure 19.2** A dorsal view of a cat skull.

- |                    |                           |
|--------------------|---------------------------|
| 1. Premaxilla      | 8. Zygomatic (malar) bone |
| 2. Nasal bone      | 9. Orbit                  |
| 3. Frontal bone    | 10. Zygomatic arch        |
| 4. Sagittal suture | 11. Temporal bone         |
| 5. Coronal suture  | 12. Parietal bone         |
| 6. Nuchal crest    | 13. Interparietal bone    |
| 7. Maxilla         |                           |



**Figure 19.3** A lateral view of a cat skull.

- |                             |                                  |
|-----------------------------|----------------------------------|
| 1. Frontal bone             | 10. Premaxilla bone              |
| 2. Parietal bone            | 11. Maxilla                      |
| 3. Squamosal suture         | 12. Zygomatic (malar) bone       |
| 4. Temporal bone            | 13. Coronoid process of mandible |
| 5. Nuchal crest             | 14. Zygomatic arch               |
| 6. External acoustic meatus | 15. Mandible                     |
| 7. Mastoid process          | 16. Condylar process of mandible |
| 8. Tympanic bulla           |                                  |
| 9. Nasal bone               |                                  |



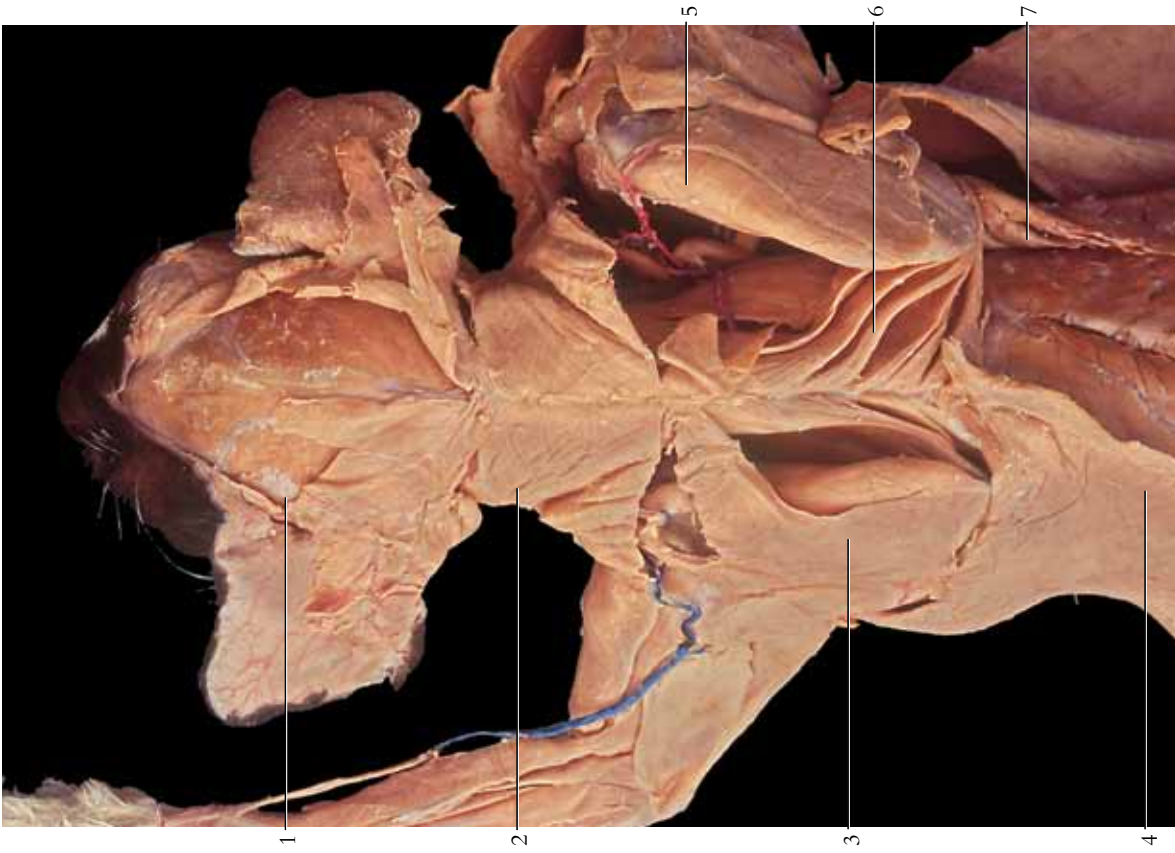
**Figure 19.4** A lateral view of the superficial muscles of the cat.

- |                                       |                                    |                                   |                        |
|---------------------------------------|------------------------------------|-----------------------------------|------------------------|
| 1. Lateral head of triceps brachii m. | 6. Acromiotrapezius m.             | 12. Latissimus dorsi m.           | 18. Gluteus maximus m. |
| 2. Acromiodeltoid m.                  | 7. Spinodeltoid m.                 | 13. External abdominal oblique m. | 19. Caudofemoralis m.  |
| 3. Clavobrachialis m. (clavodeltoid)  | 8. Long head of triceps brachii m. | 14. Lumbodorsal fascia            | 20. Biceps femoris m.  |
| 4. Sternomastoid m.                   | 9. Pectoralis minor m.             | 15. Sartorius m.                  |                        |
| 5. Clavotrapezius m.                  | 10. Xiphohumeralis m.              | 16. Tensor fasciae latae m.       |                        |
|                                       | 11. Spinotrapezius m.              | 17. Gluteus medius m.             |                        |



**Figure 19.5** A dorsal view of the superficial muscles of the cat.

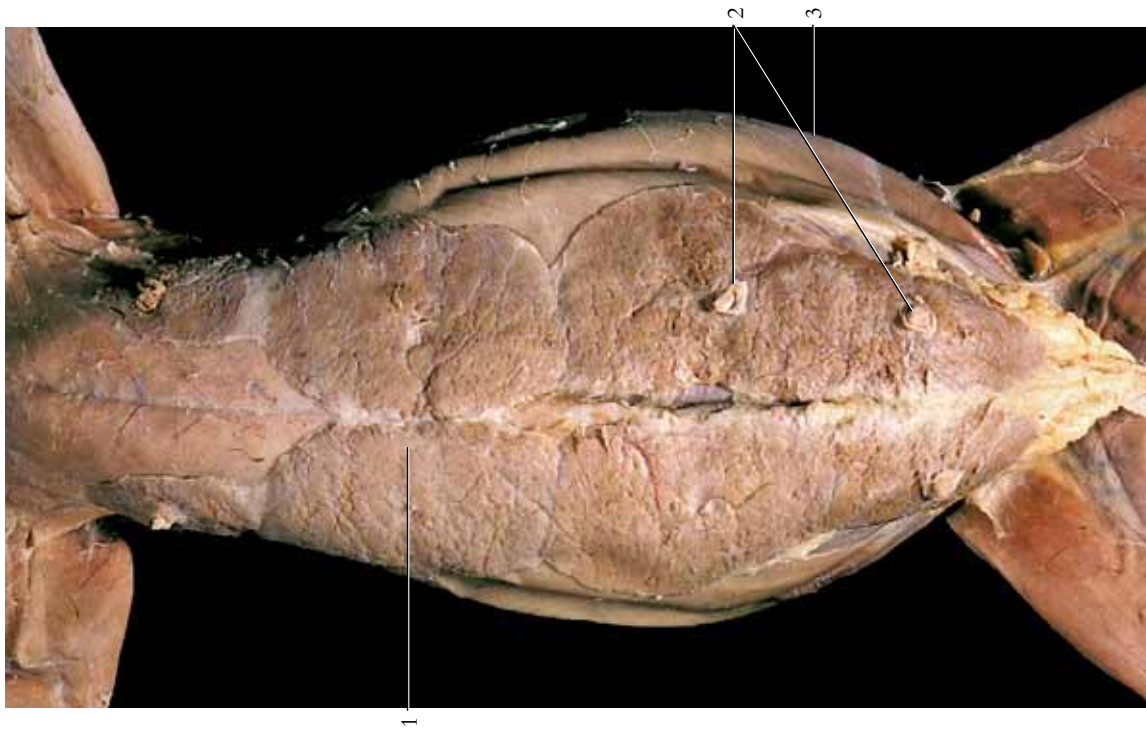
1. Lateral head of triceps brachii m.
2. Acromiortrapezius m.
3. Latissimus dorsi m.
4. Lumbodorsal fascia
5. Sacrospinalis m.
6. Gluteus medius m.
7. Caudal m.
8. Supraspinatus m.
9. Rhomboid m.
10. Serratus anterior m.
11. Latissimus dorsi m.
12. Gluteus maximus m.
13. Caudofemoralis m.



**Figure 19.6** A dorsal view of the cat neck and thorax.

1. Temporalis m.
2. Clavotrapezius m.
3. Acromiortrapezius m.
4. Latissimus dorsi m.
5. Supraspinatus m.
6. Rhomboid m.
7. Serratus anterior m.





**Figure 19.7** A superficial view of the ventral trunk.

1. Mammary glands
2. Nipples
3. External abdominal oblique m.



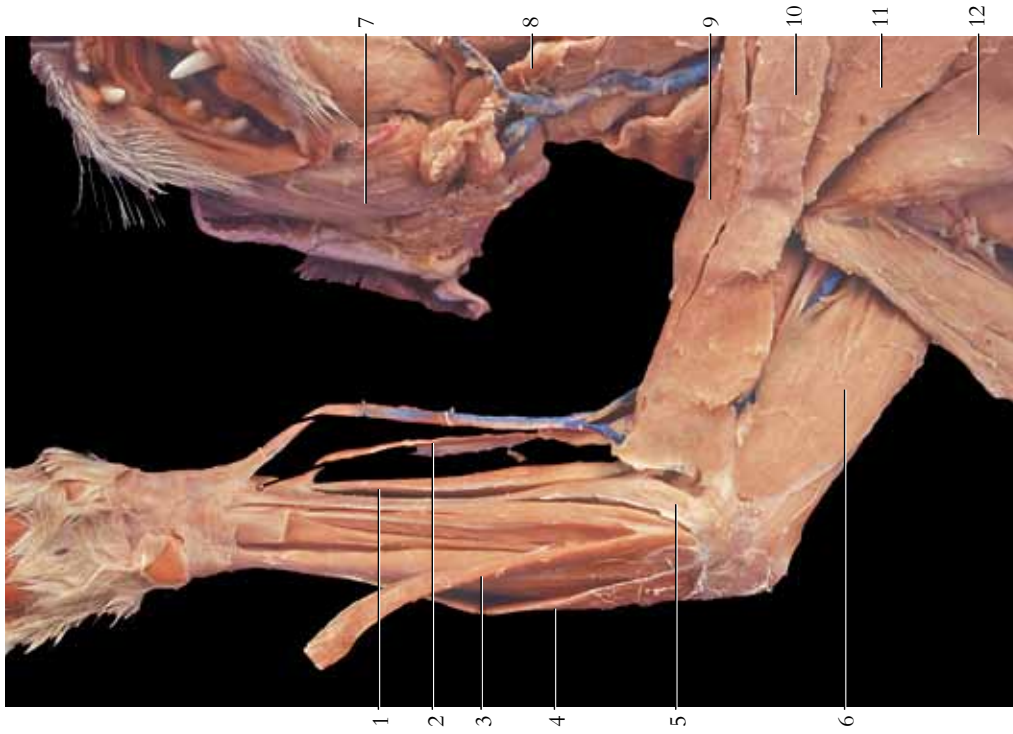
**Figure 19.8** A ventral view of the neck and thorax.

1. Digastric m.
2. Mylohyoid m.
3. Sternohyoid m.
4. Sternomastoid m.
5. Clavotrapezius m.
6. Masseter m.
7. Clavobrachialis m.
8. Pectoantebrachialis m. (clavodeltoid)
9. Pectoralis major m.
10. Pectoralis minor m.



**Figure 19.9** A lateral view of the shoulder and brachium.

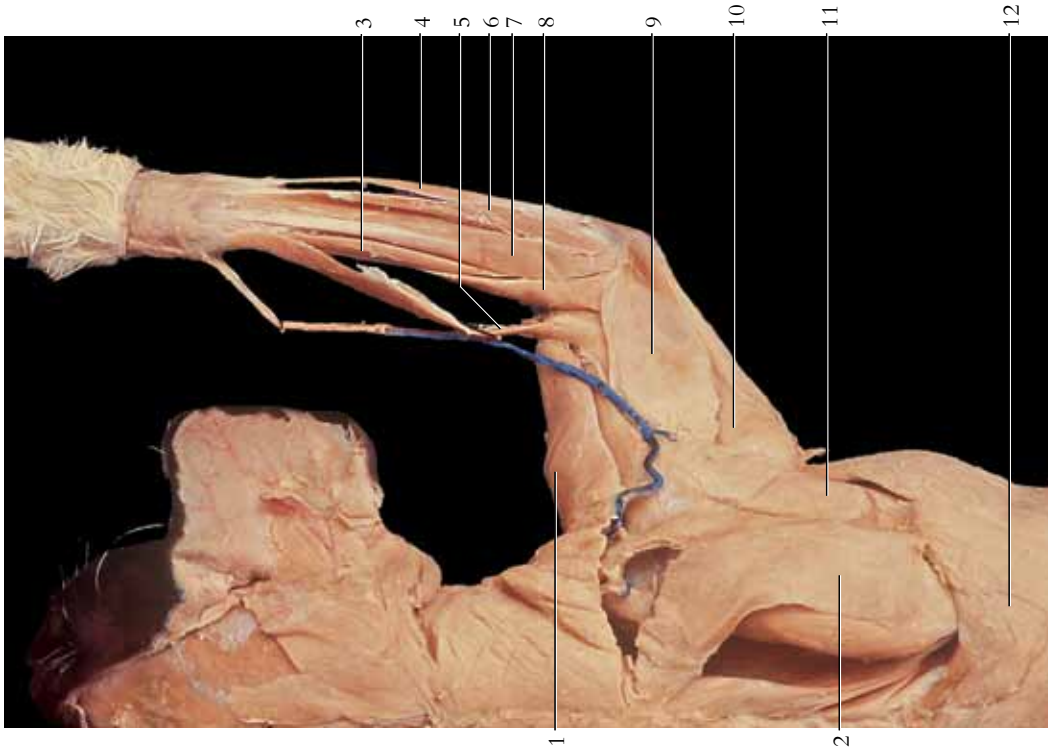
1. Acromiotrapipezius m.
2. Levator scapulae ventralis m.
3. Spinodeltoid m.
4. Latissimus dorsi m.
5. Long head of triceps brachii m.
6. Clavobrachialis m. (clavodeltioid)
7. Lateral head of triceps brachii m.
8. Clavotrapezius m.
9. Parotid gland
10. Acromiodeltoid m.
11. Brachioradialis m.



**Figure 19.10** An anterior view of the brachium and antebrachium.

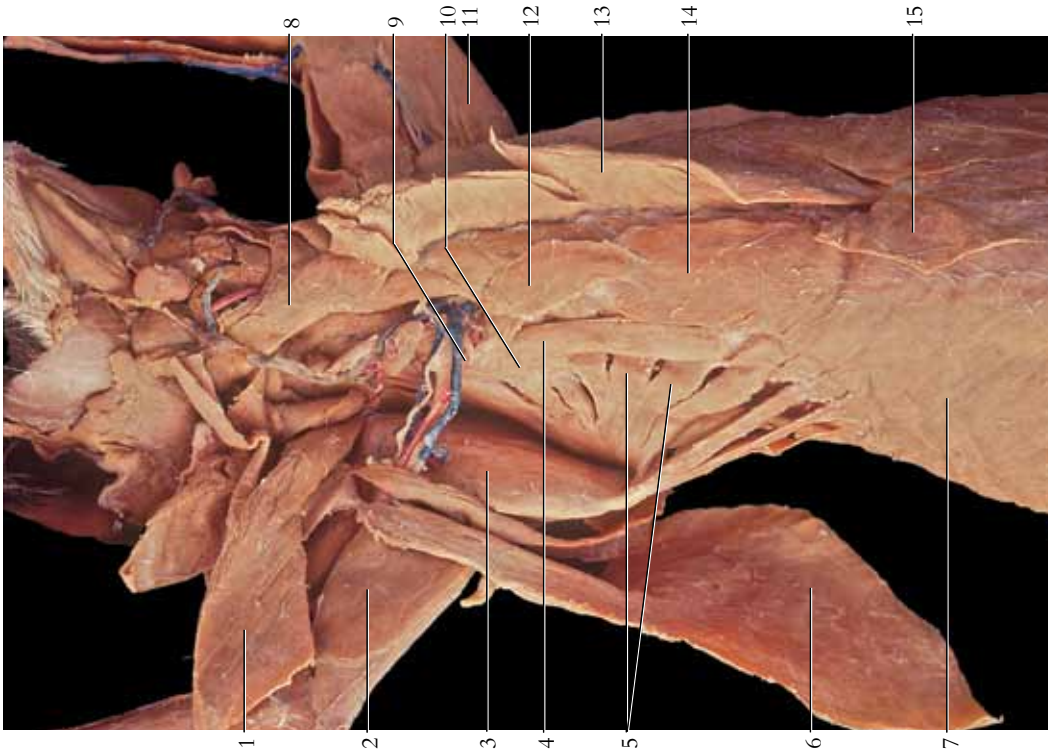
1. Extensor carpi radialis longus m.
2. Brachioradialis m.
3. Palmaris longus m. (cut)
4. Flexor carpi ulnaris m.
5. Pronator teres m.
6. Epitrochlearis
7. Masseter m.
8. Sternomastoid m.
9. Clavobrachialis m. (clavodeltioid)
10. Pectoantebrachialis m.
11. Pectoralis major m.
12. Pectoralis minor m.





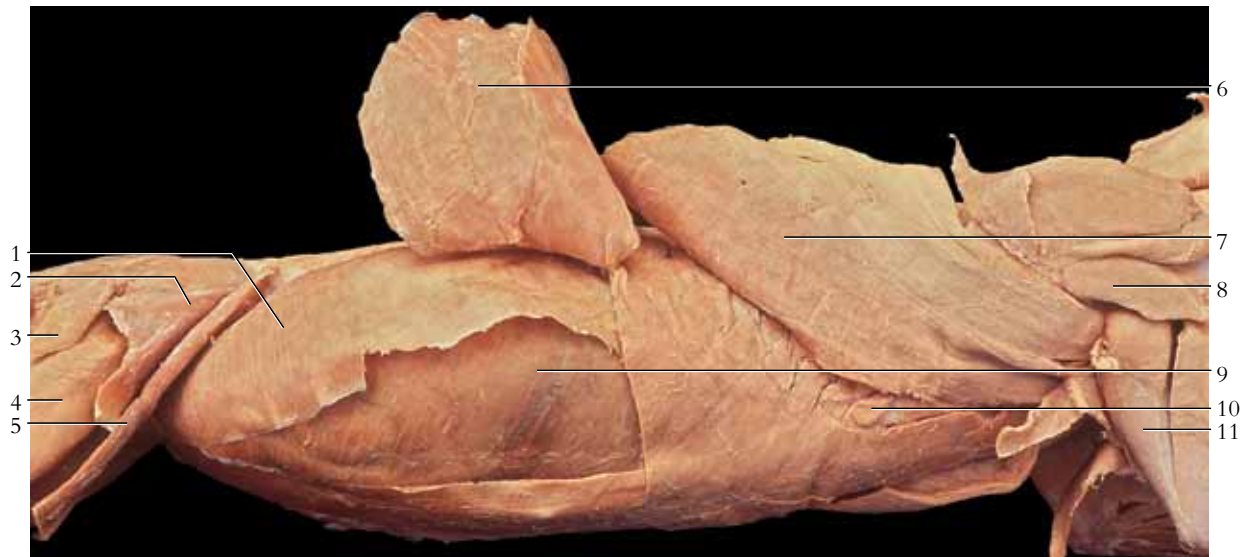
**Figure 19.11** A posterior view of the brachium and antebrachium.

1. Clavobrachialis m.
2. Acromiotrapius m.
3. Extensor carpi radialis brevis m.
4. Extensor carpi ulnaris m.
5. Brachioradialis m.
6. Extensor digitorum lateralis m.
7. Extensor digitorum communis m.
8. Extensor carpi radialis longus m.
9. Lateral head of triceps brachii m.
10. Long head of triceps brachii m.
11. Spinodeltoid m.
12. Latissimus dorsi m.



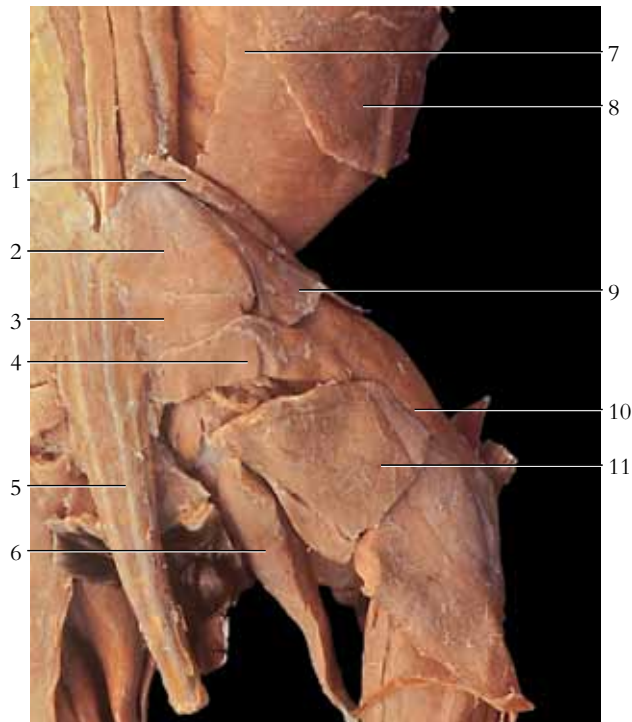
**Figure 19.12** An anterior view of the trunk.

1. Pectoralis minor (cut)
2. Epitrochlearis m.
3. Subscapularis m.
4. Scalenus medius m.
5. Serratus anterior m.
6. Latissimus dorsi m. (cut)
7. External abdominal oblique m.
8. Sternomastoid m.
9. Scalenus anterior m.
10. Scalenus posterior m.
11. Epitrochlearis m.
12. Transverse costarum m.
13. Pectoralis minor m. (cut and reflected)
14. Rectus abdominis m.
15. Xiphohumeralis m. (cut)



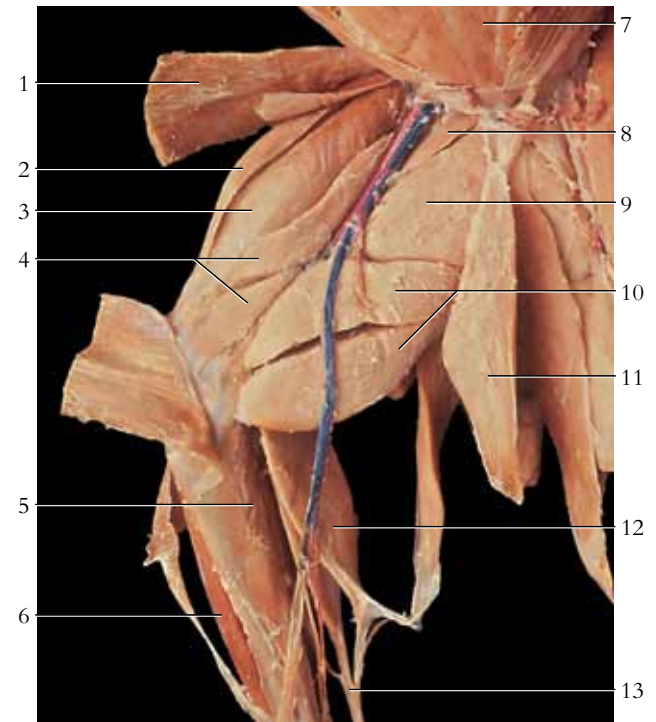
**Figure 19.13** A lateral view of the trunk.

- |                                  |  |                                     |
|----------------------------------|--|-------------------------------------|
| 1. Internal abdominal oblique m. | 5. Sartorius m.                                      | 8. Spinodeltoid m.                  |
| 2. Tensor fasciae latae          | 6. External abdominal oblique m. (cut and reflected) | 9. Transverse abdominis m.          |
| 3. Caudofemoralis m.             | 7. Latissimus dorsi m.                               | 10. Serratus anterior m.            |
| 4. Vastus lateralis m.           |  | 11. Long head of triceps brachii m. |



**Figure 19.14** A lateral view of the superficial thigh.

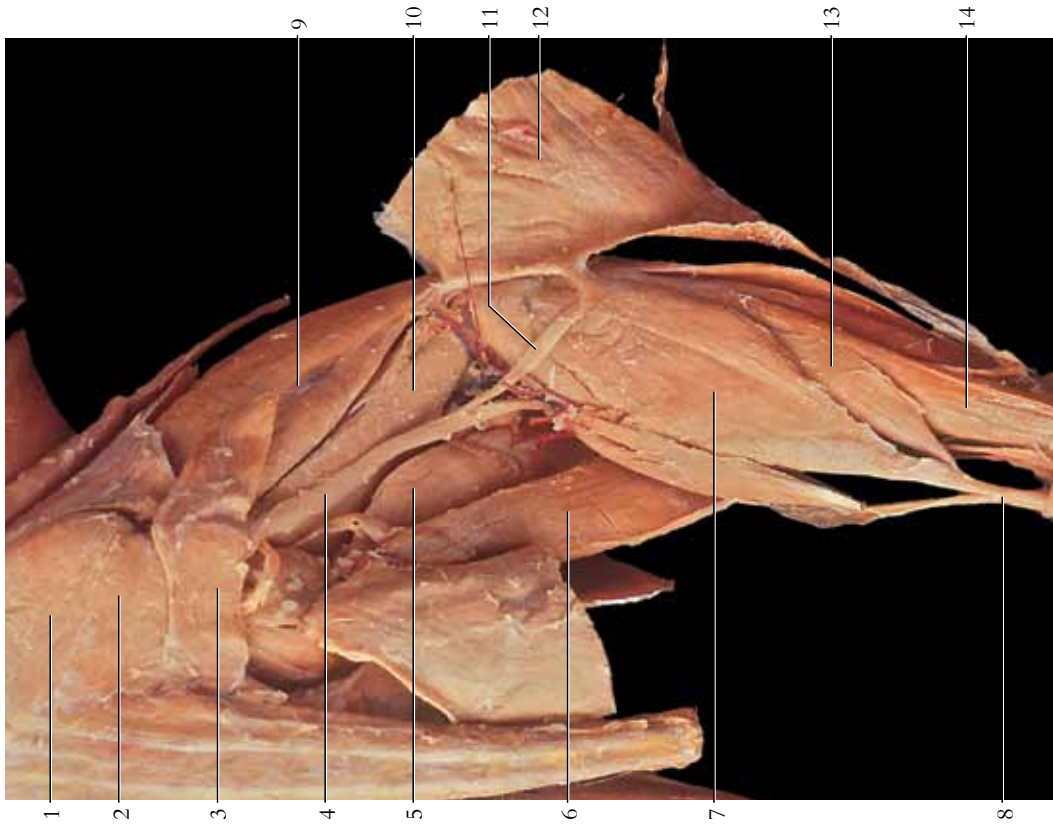
- |                                  |                                  |
|----------------------------------|----------------------------------|
| 1. Sartorius m.                  | 8. External abdominal oblique m. |
| 2. Gluteus medius m.             | 9. Tensor fasciae latae (cut)    |
| 3. Gluteus maximus m.            | 10. Vastus lateralis m.          |
| 4. Caudofemoralis m.             | 11. Biceps femoris m.            |
| 5. Caudal m.                     |                                  |
| 6. Semitendinosus m.             |                                  |
| 7. Internal abdominal oblique m. |                                  |



**Figure 19.15** A medial view of the thigh and leg.

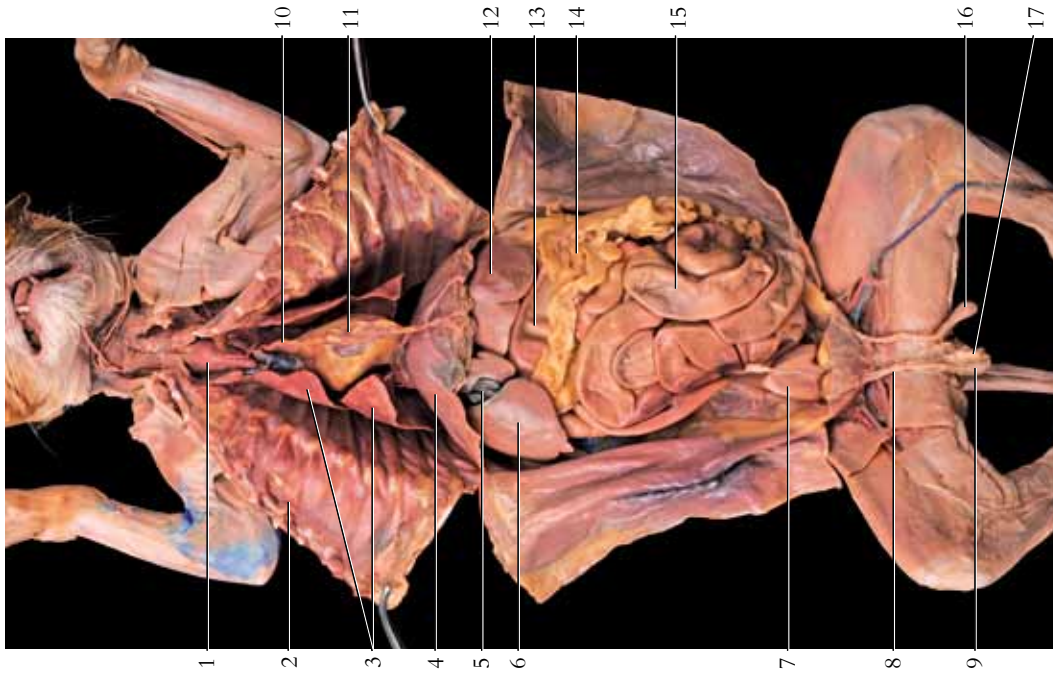
- |                               |                                       |
|-------------------------------|---------------------------------------|
| 1. Sartorius m. (cut)         | 8. Adductor longus m.                 |
| 2. Vastus lateralis m.        | 9. Adductor femoris m.                |
| 3. Rectus femoris m.          | 10. Semimembranosus m.                |
| 4. Vastus medialis m.         | 11. Gracilis m. (cut)                 |
| 5. Flexor digitorum longus m. | 12. Gastrocnemius m.                  |
| 6. Tibialis anterior m.       | 13. Tendo calcaneus (Achilles tendon) |
| 7. Rectus abdominus m.        |                                       |





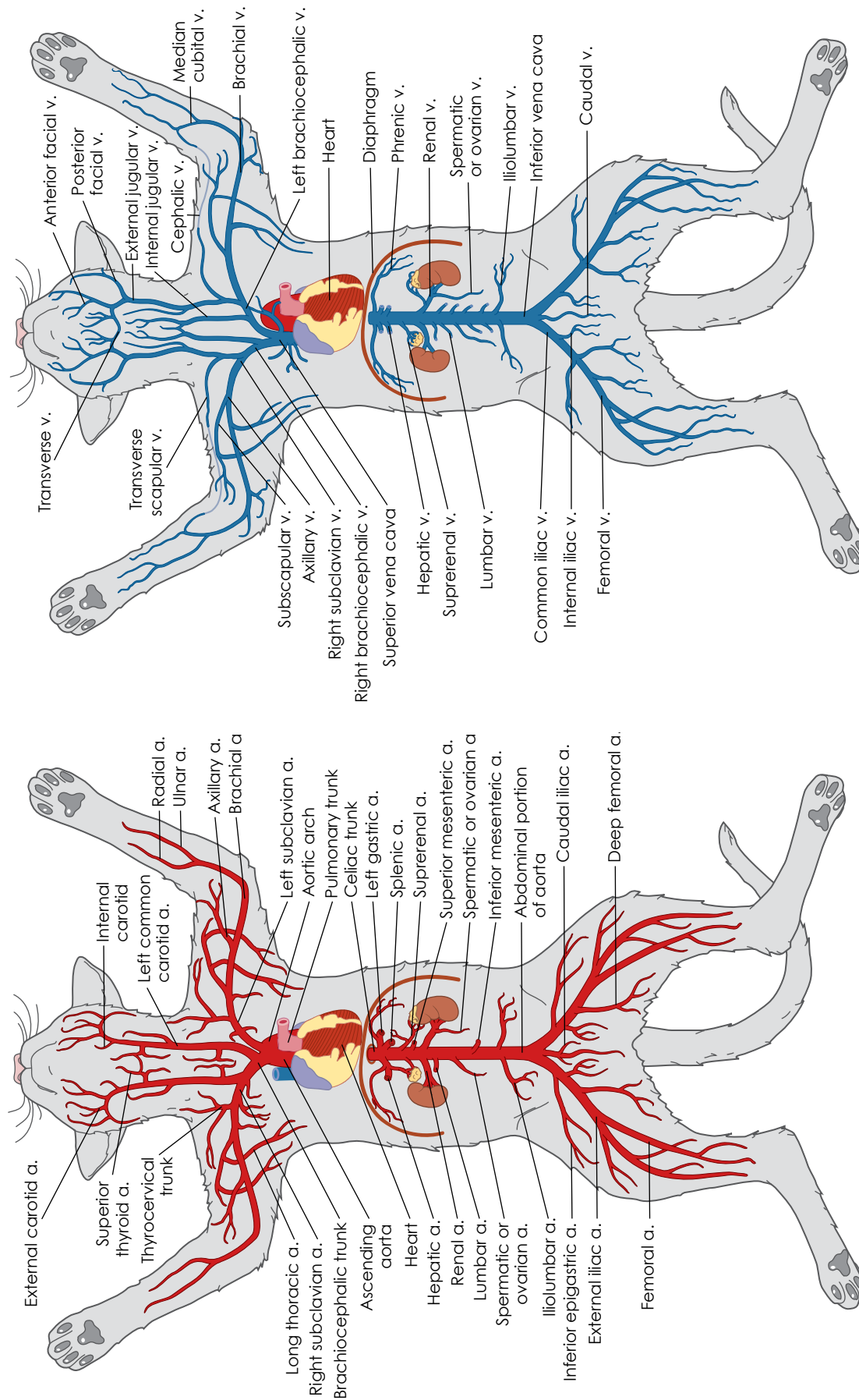
**Figure 19.16** A lateral view of the thigh and leg.

1. Gluteus medius m.
2. Gluteus maximus m.
3. Caudofemoralis m.
4. Sciatic nerve
5. Semimembranosus m.
6. Semitendinosus m.
7. Gastrocnemius m.
8. Tendo calcaneus
9. Vastus lateralis m.
10. Adductor femoris m.
11. Tenuissimus m.
12. Biceps femoris m. (cut and reflected)
13. Soleus m.
14. Fibularis (peroneal) m.



**Figure 19.17** The viscera intact.

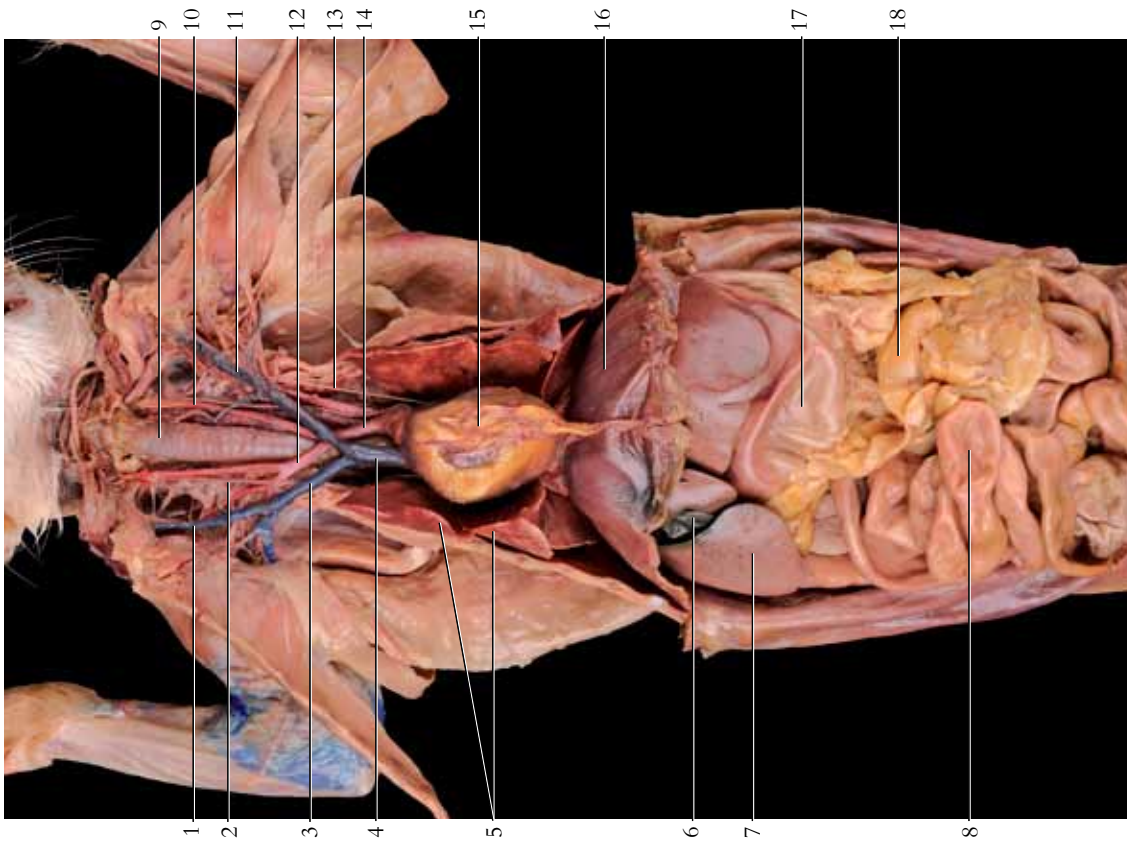
1. Thyroid gland
2. Internal thoracic artery
3. Lung
4. Diaphragm
5. Gallbladder
6. Liver
7. Urinary bladder
8. Spermatocord
9. Right testicle (with partial scrotum)
10. Thymus
11. Heart (within pericardium)
12. Liver
13. Stomach
14. Greater omentum
15. Intestines
16. Left testicle
17. Penis



**Figure 19.18** The principal arteries of the cat, ventral view. (a.=artery)

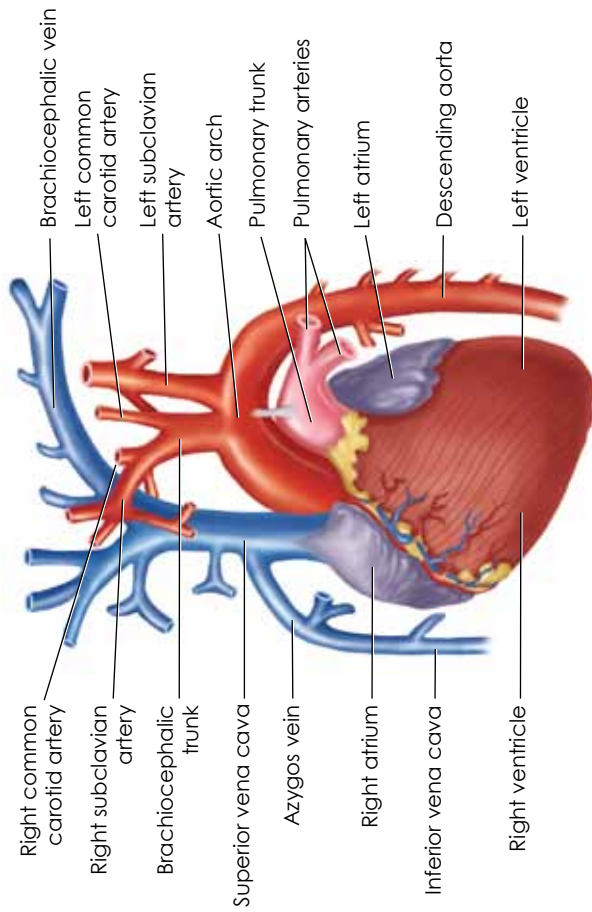
**Figure 19.19** The principal veins of the cat, ventral view. (v.=vein)



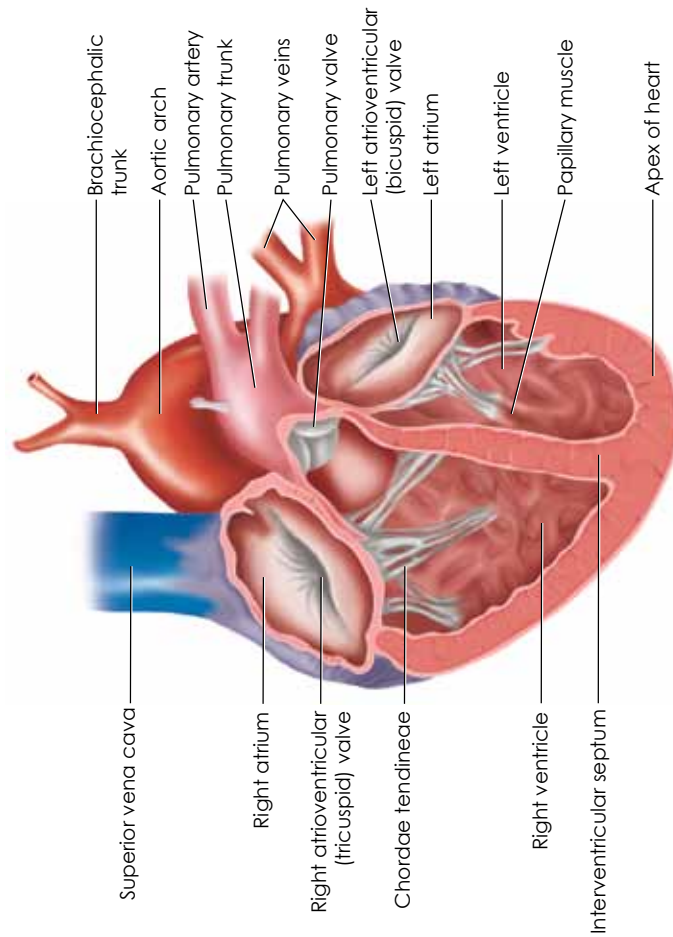


**Figure 19.22** The cat heart within the pericardium.

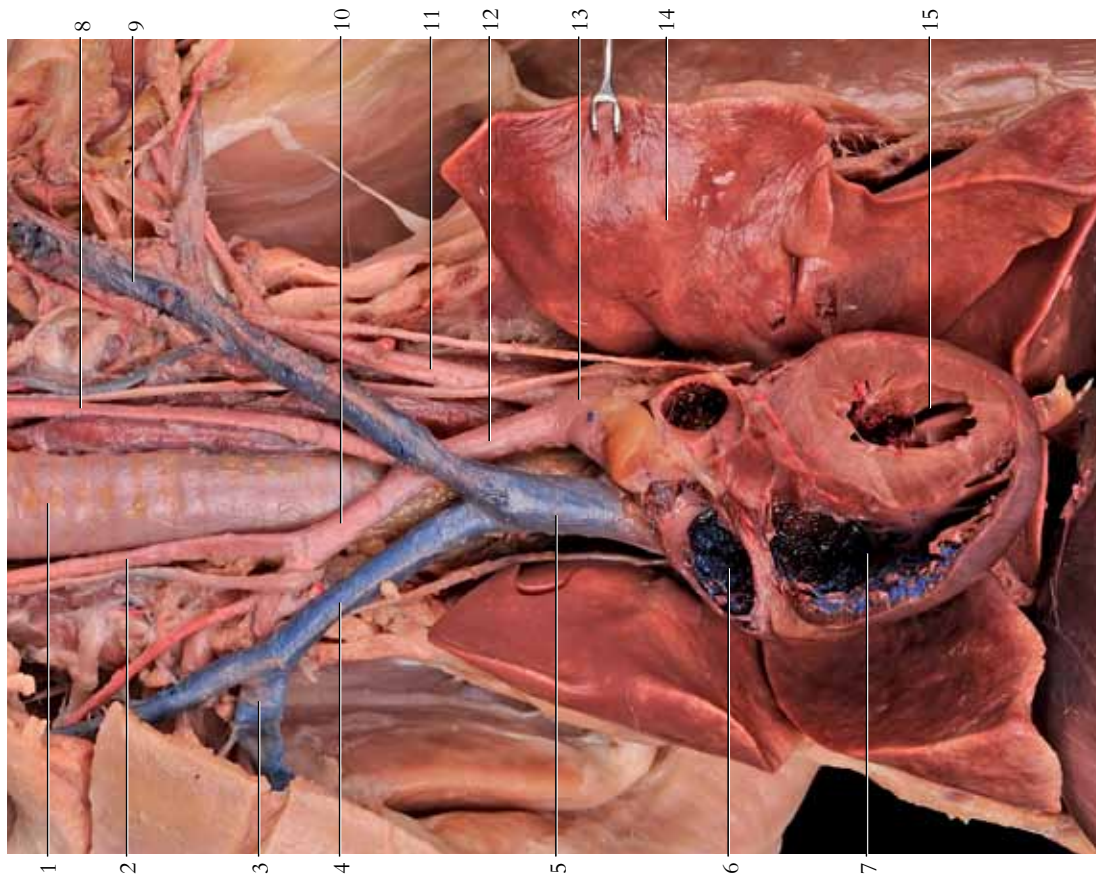
1. External jugular vein
2. Vagus nerve
3. Right brachiocephalic vein
4. Cranial (superior) vena cava
5. Lung
6. Gallbladder
7. Liver
8. Small intestines
9. Trachea
10. Left carotid artery
11. External jugular vein
12. Common carotid artery
13. Phrenic nerve
14. Brachiocephalic trunk
15. Heart within pericardium
16. Diaphragm
17. Stomach
18. Greater omentum



**Figure 19.20** The cat heart and associated vessels.

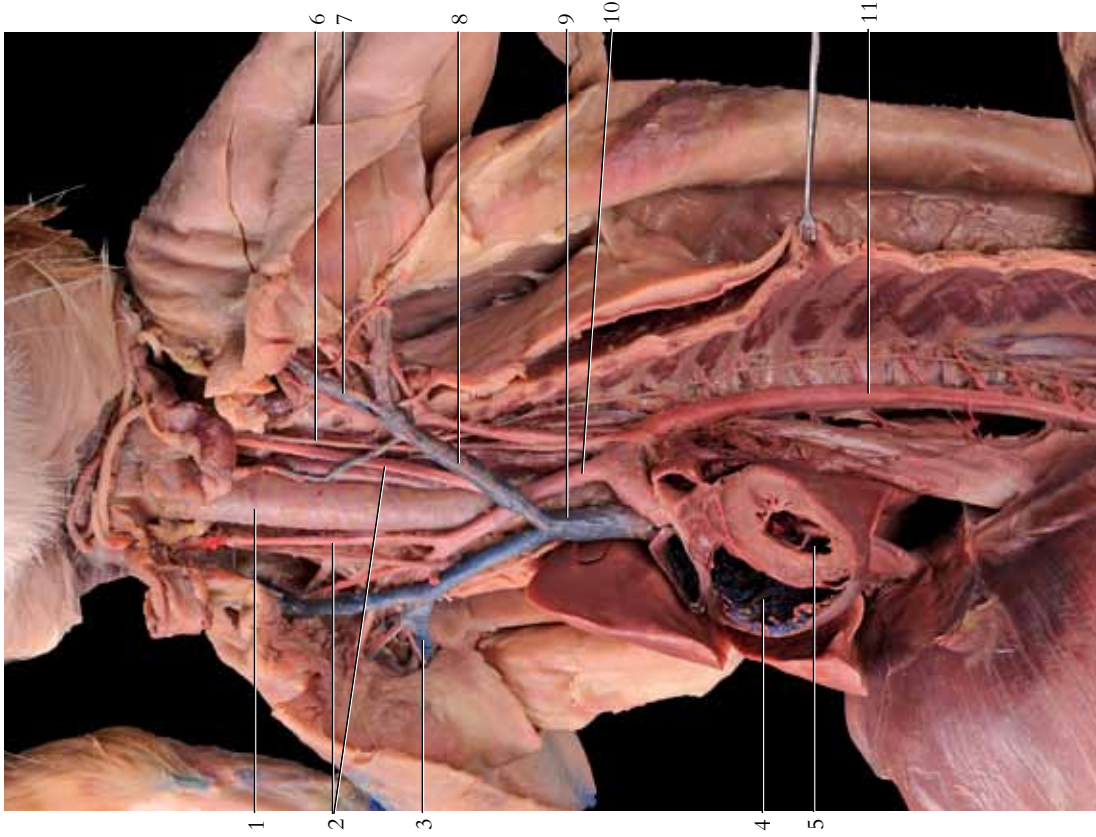


**Figure 19.21** The internal anatomy of the cat heart.



**Figure 19.23** An internal view of the heart.

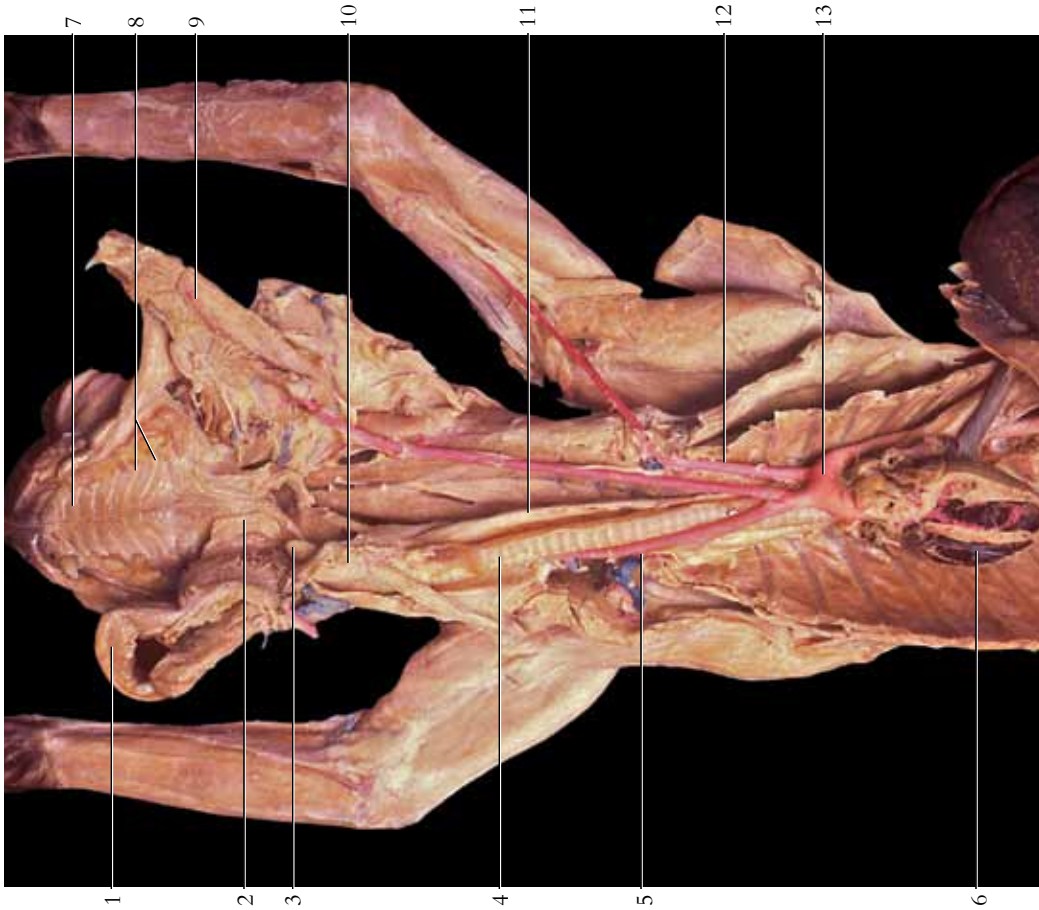
1. Trachea
2. Right common carotid artery
3. Right subclavian vein
4. Right brachiocephalic vein
5. Cranial (superior) vena cava
6. Right atrium
7. Right ventricle
8. Left common carotid artery
9. External jugular vein
10. Right common carotid artery
11. Left subclavian artery
12. Brachiocephalic trunk
13. Aortic arch
14. Lung
15. Left ventricle



**Figure 19.24** The heart and surrounding structures.

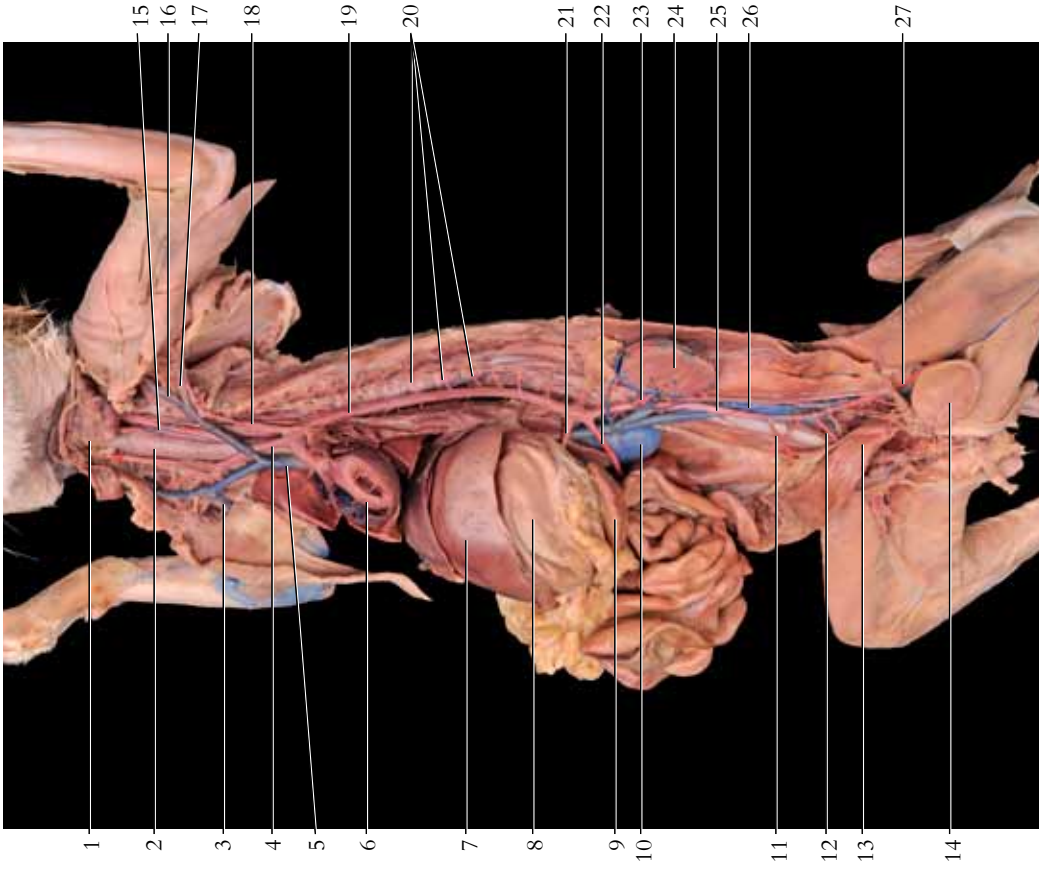
1. Trachea
2. Common carotid arteries
3. Axillary vein
4. Right ventricle
5. Left ventricle
6. Vagus nerve
7. External jugular vein
8. Left brachiocephalic vein
9. Cranial (superior) vena cava
10. Brachiocephalic trunk
11. Dorsal (descending) aorta





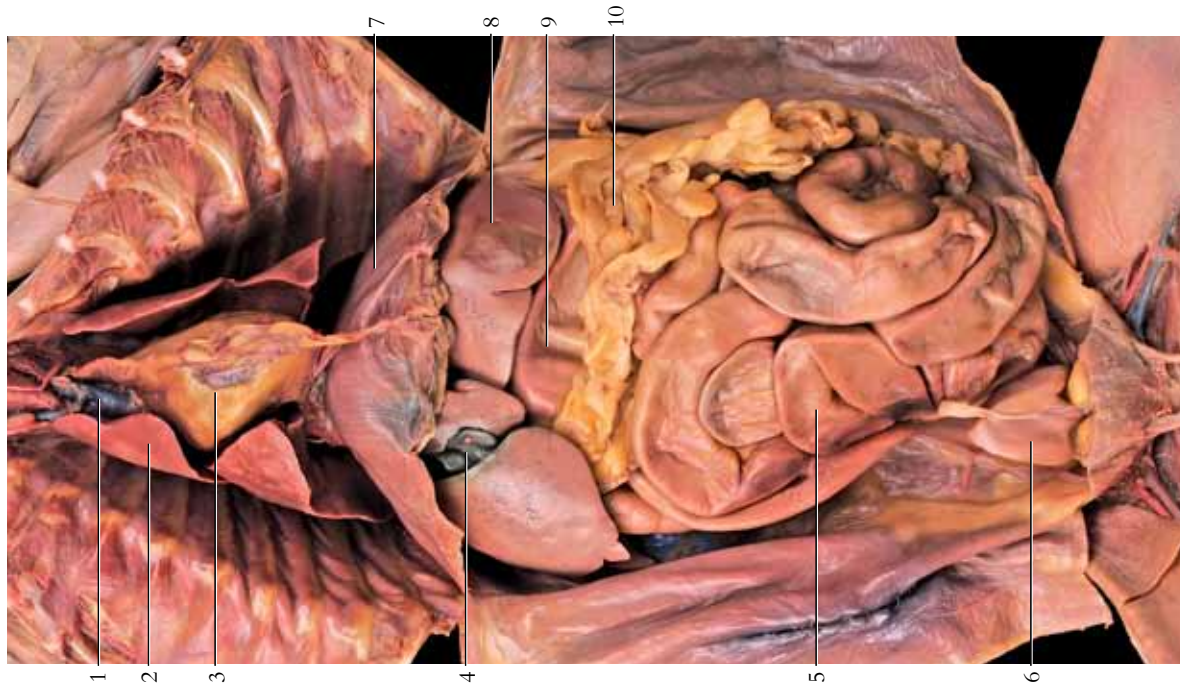
**Figure 19.25** The upper gastrointestinal and respiratory structures of the cat.

1. Tongue
2. Soft palate
3. Epiglottis
4. Trachea
5. Right common carotid artery
6. Heart (cut)
7. Hard palate
8. Palatal rugae
9. Mandible (cut)
10. Larynx
11. Esophagus
12. Left subclavian artery
13. Aortic arch



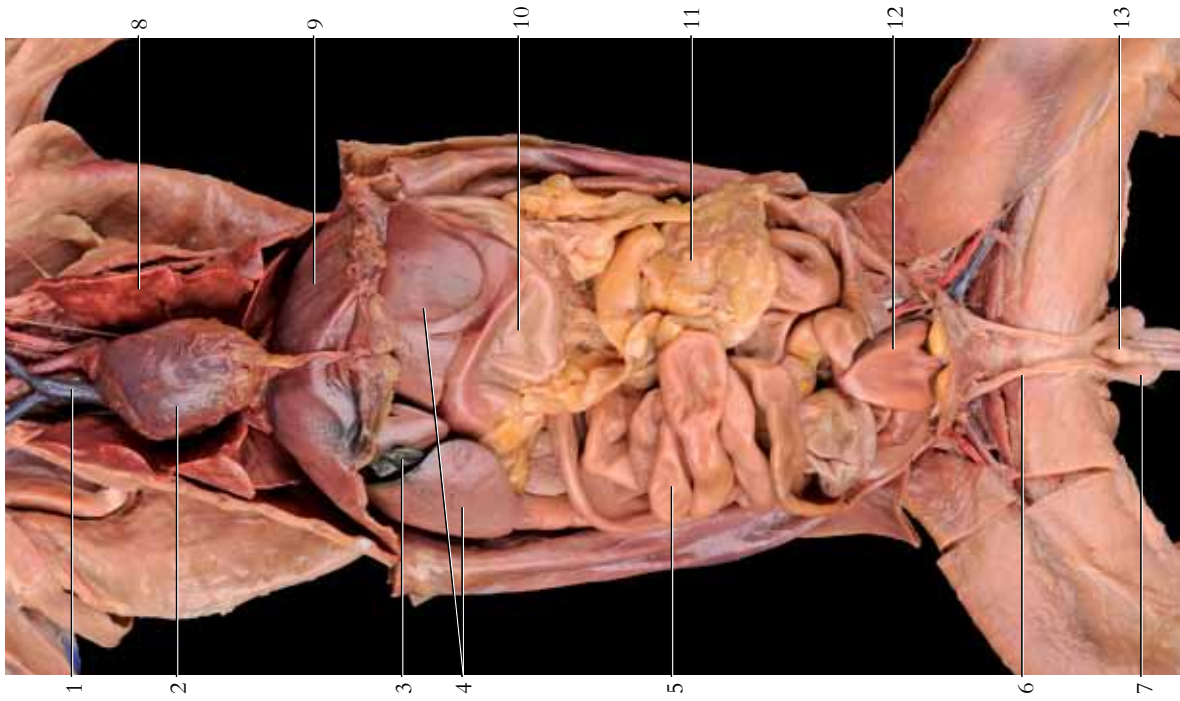
**Figure 19.26** An anterior view of the arteries and veins of the trunk of a cat.

1. Larynx
2. Trachea
3. Right subclavian vein
4. Brachiocephalic trunk
5. Cranial (superior) vena cava
6. Heart (cut)
7. Liver
8. Stomach
9. Spleen
10. Right kidney
11. Inferior mesenteric artery
12. Common iliac artery
13. Colon
14. Urinary bladder
15. Internal jugular vein
16. External jugular vein
17. Left subclavian vein
18. Left subclavian artery
19. Thoracic aorta
20. Intercostal arteries
21. Celiac trunk
22. Superior mesenteric artery
23. Renal artery
24. Left kidney (cut)
25. Abdominal aorta
26. Testicular artery
27. Femoral artery



**Figure 19.27** An anterior view of the abdominal viscera.

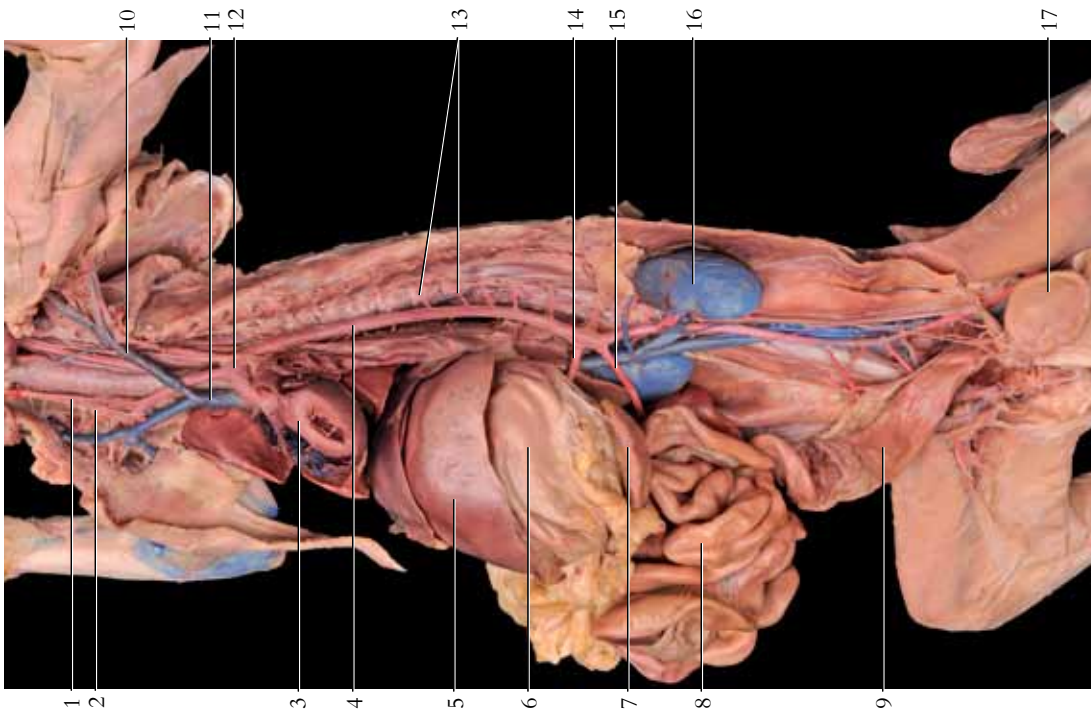
1. Cranial (superior) vena cava
2. Lung
3. Heart within pericardium
4. Gallbladder
5. Small intestine
6. Urinary bladder
7. Diaphragm
8. Liver
9. Stomach
10. Greater omentum



**Figure 19.28** An anterior view of the viscera.

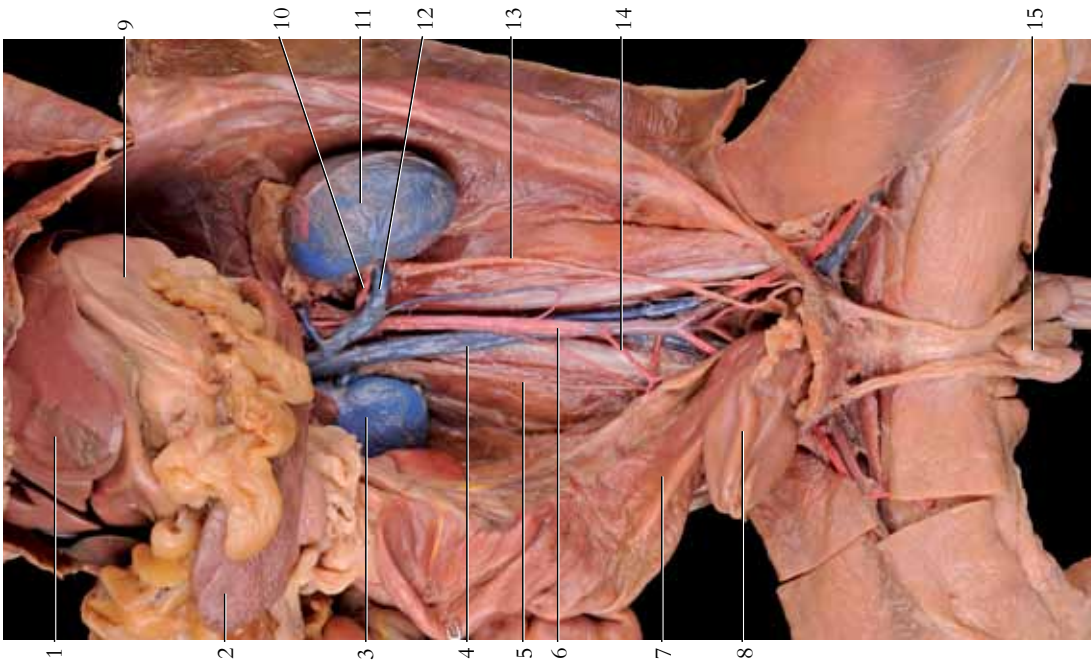
1. Cranial (superior) vena cava
2. Heart
3. Gallbladder
4. Liver
5. Small intestine
6. Spermatoc cord
7. Right testicle
8. Lung
9. Diaphragm
10. Stomach
11. Greater omentum
12. Urinary bladder
13. Penis





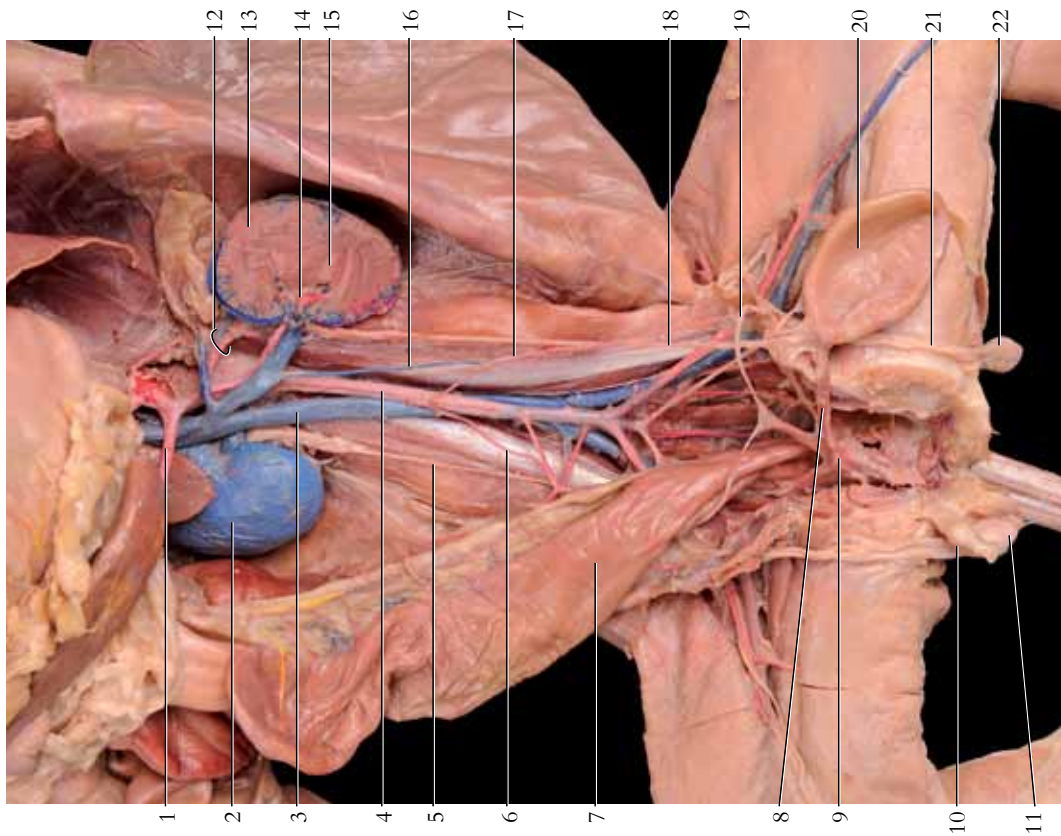
**Figure 19.29** An anterior view of the deep structures of the trunk.

1. Right common carotid artery
2. Vagus nerve
3. Heart (cut)
4. Thoracic aorta
5. Liver
6. Stomach
7. Spleen
8. Small intestine
9. Colon
10. Left brachiocephalic vein
11. Cranial (superior) vena cava
12. Aortic arch
13. Intercostal artery
14. Celiac trunk
15. Superior mesenteric artery
16. Kidney
17. Urinary bladder

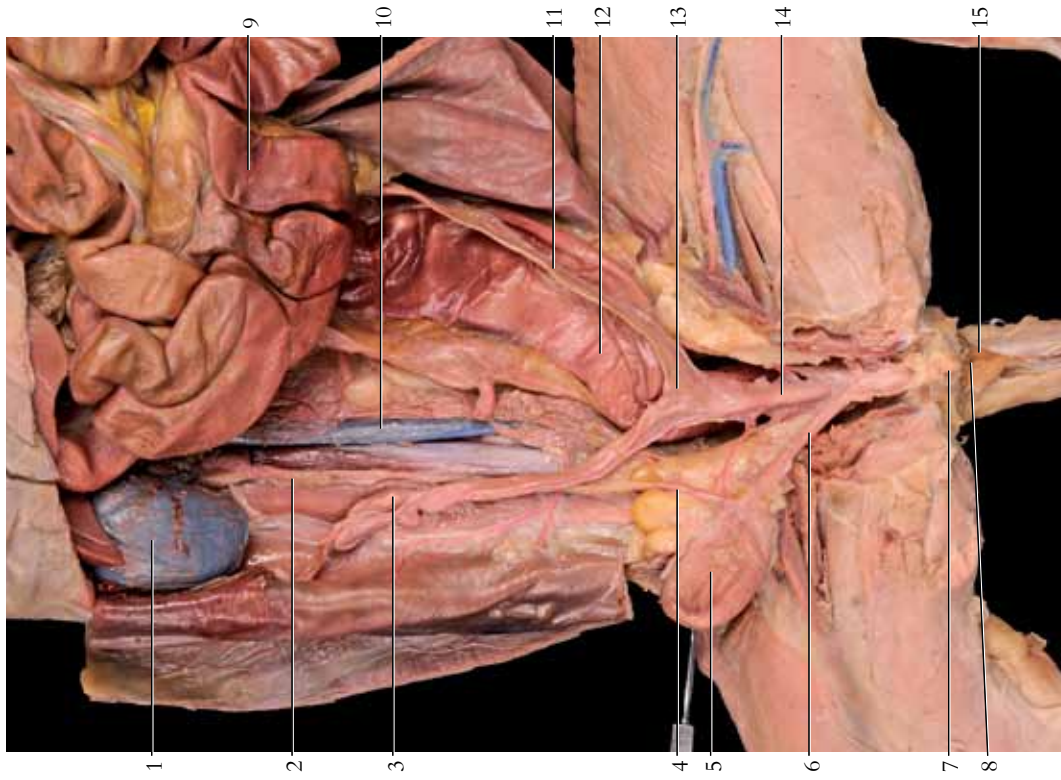


**Figure 19.30** The urinary system.

1. Liver
2. Spleen (reflected)
3. Right kidney
4. Caudal (inferior) vena cava
5. Right ureter
6. Abdominal aorta
7. Colon
8. Urinary bladder
9. Stomach
10. Renal artery
11. Left kidney
12. Renal vein
13. Left ureter
14. Inferior mesenteric artery
15. Penis

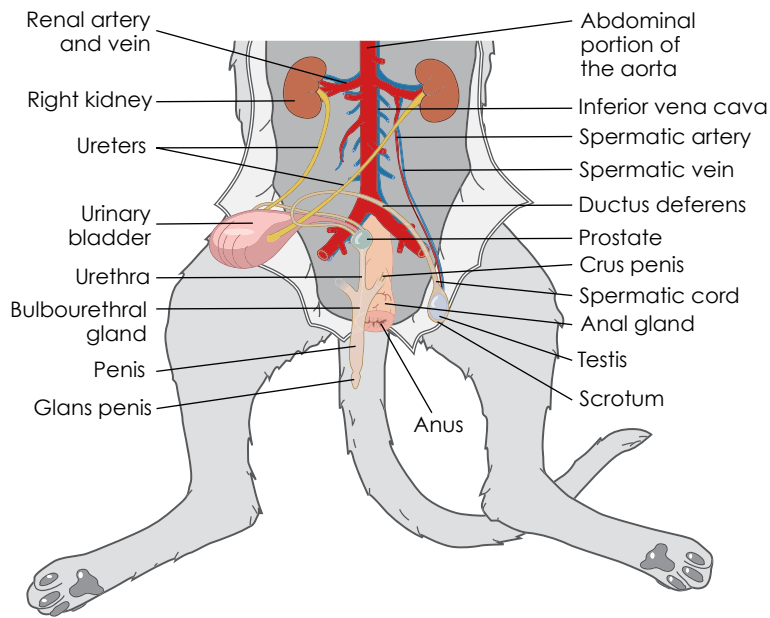
**Figure 19.31** The urogenital system of a male cat.

1. Superior mesenteric artery
2. Kidney
3. Caudal (inferior) vena cava
4. Abdominal aorta
5. Right ureter
6. Right testicular artery
7. Colon
8. Urethra
9. Prostate
10. Penis
11. Right testis
12. Renal artery and vein
13. Renal cortex
14. Renal pelvis
15. Renal medulla
16. Left testicular vein
17. Left testicular artery
18. Left ureter
19. Ductus (vas) deferens
20. Urinary bladder
21. Spermatic cord
22. Left testis

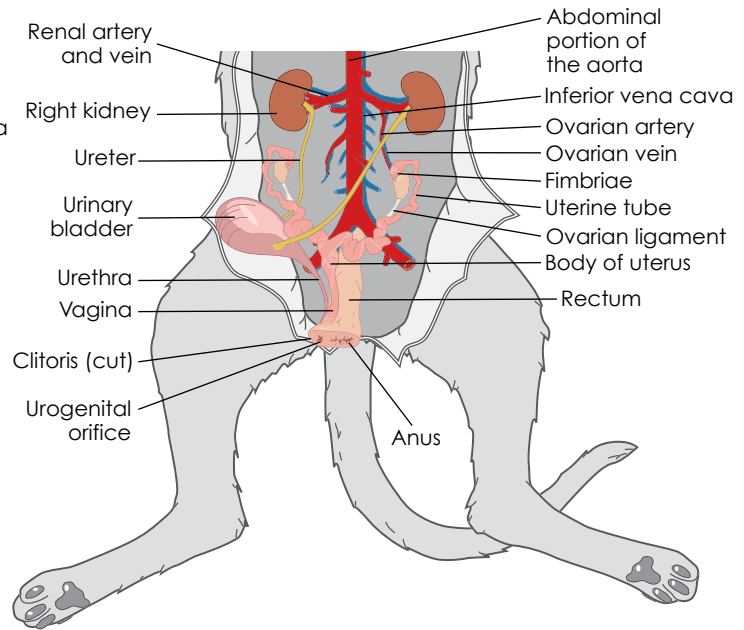
**Figure 19.32** The urogenital system of a female cat.

1. Kidney
2. Ureter
3. Ovary
4. Ureter
5. Urinary bladder
6. Urethra
7. Clitoris
8. Vestibule
9. Small intestine
10. Caudal (inferior) vena cava
11. Horn of uterus
12. Colon
13. Body of uterus
14. Vagina
15. Labia

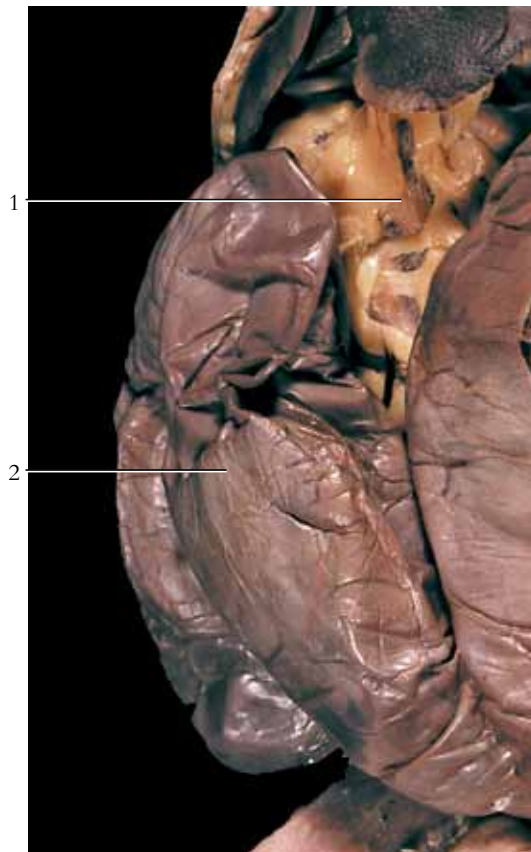




**Figure 19.33** A diagram of the urogenital system of a male cat.

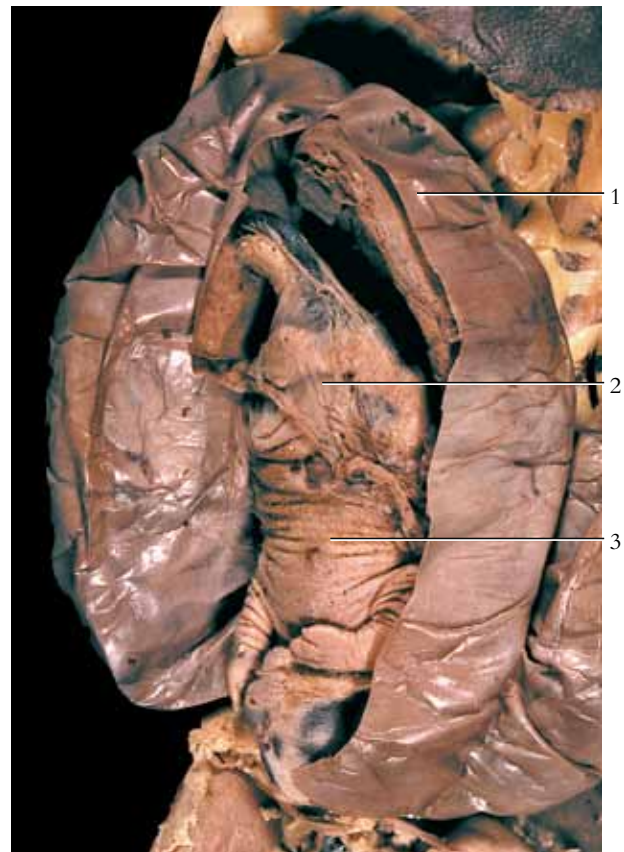


**Figure 19.34** A diagram of the urogenital system of a female cat.



**Figure 19.35** The abdominal cavity of a pregnant cat.

1. Greater omentum
2. Right horn of uterus



**Figure 19.36** The abdominal cavity of a pregnant cat.

1. Uterine wall (cut)
2. Amniotic sac enclosing fetus
3. Fetus

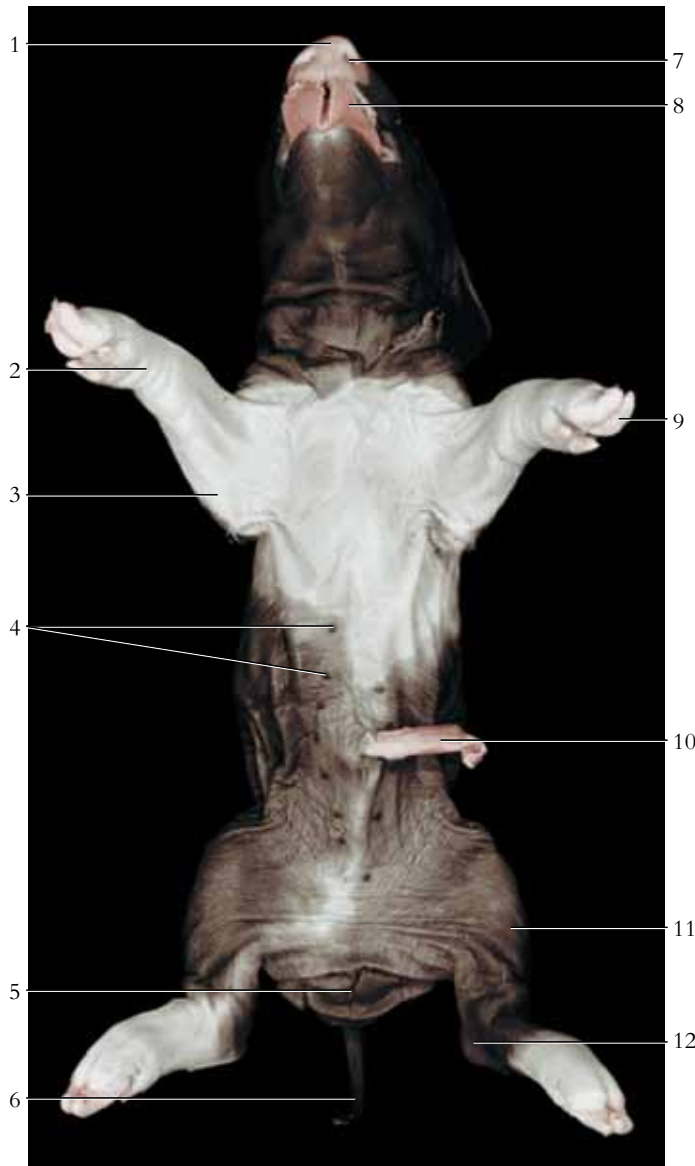
# Chapter 20

## Fetal Pig Dissection

Because much can be learned from dissecting embalmed fetal pig specimens, they are frequently utilized in anatomy laboratories. Fetal pigs are purchased from biological supply houses and are specially prepared for dissection. Excess embalming fluid should be drained from the packaged specimen prior to dissection.

Examine your specimen and identify the **umbilical cord** attached to the ventral surface of the abdomen. Locate the two rows of **teats** that extend the length of the abdomen. Determine the sex of your specimen. A male has a **scrotal sac** in the pelvic region of the body between the hind legs and a **urogenital opening** just caudal to the umbilical cord. The **penis** can be palpated as a muscular tubular structure just underneath the skin along the midline proceeding caudally from the urogenital opening. A female has a small fleshy **genital papilla** projecting from the urogenital opening, which is located immediately ventral to the **anal opening**.

Before the muscles and viscera of a fetal pig can be studied, the specimen's skin has to be removed according to the following suggested guidelines.

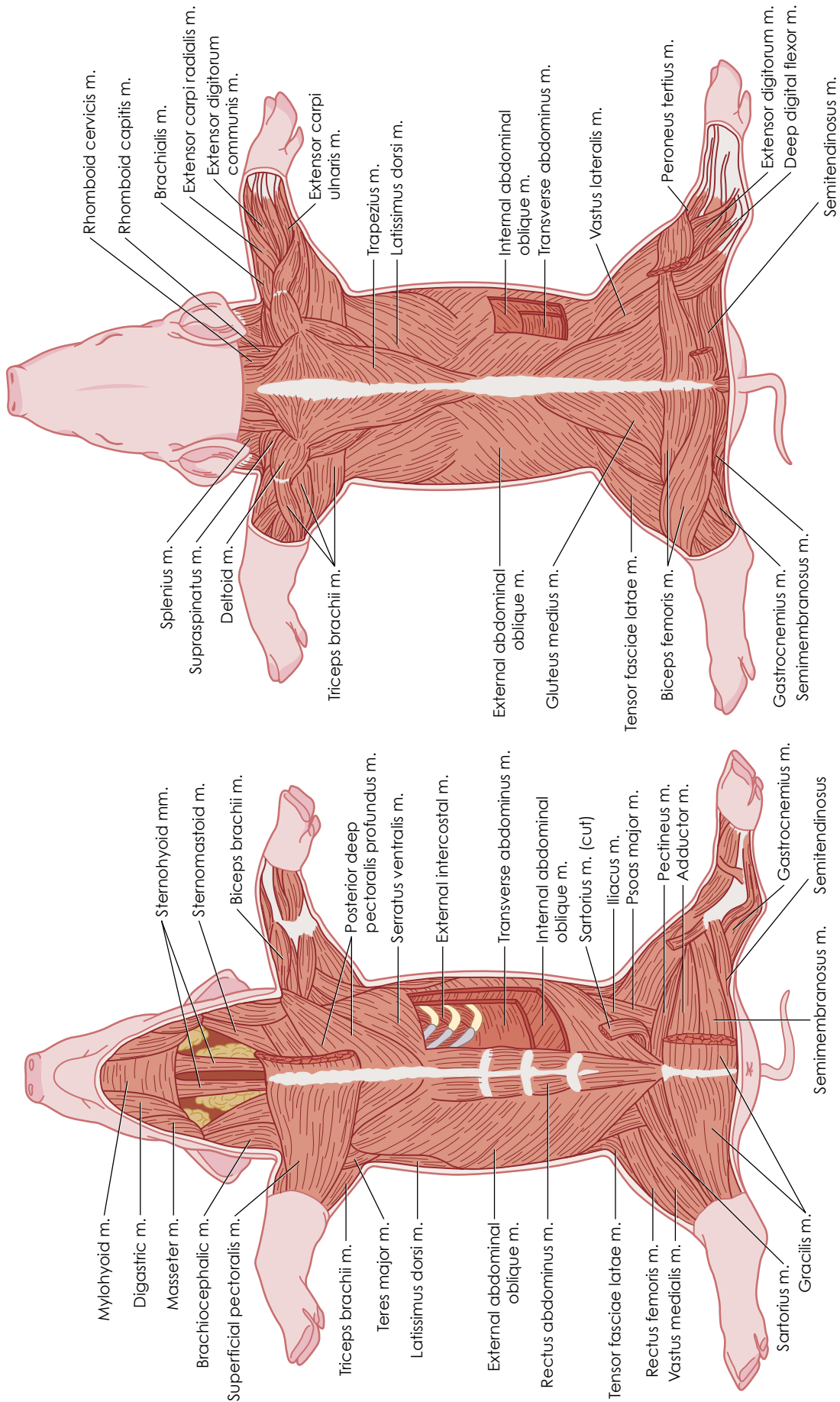


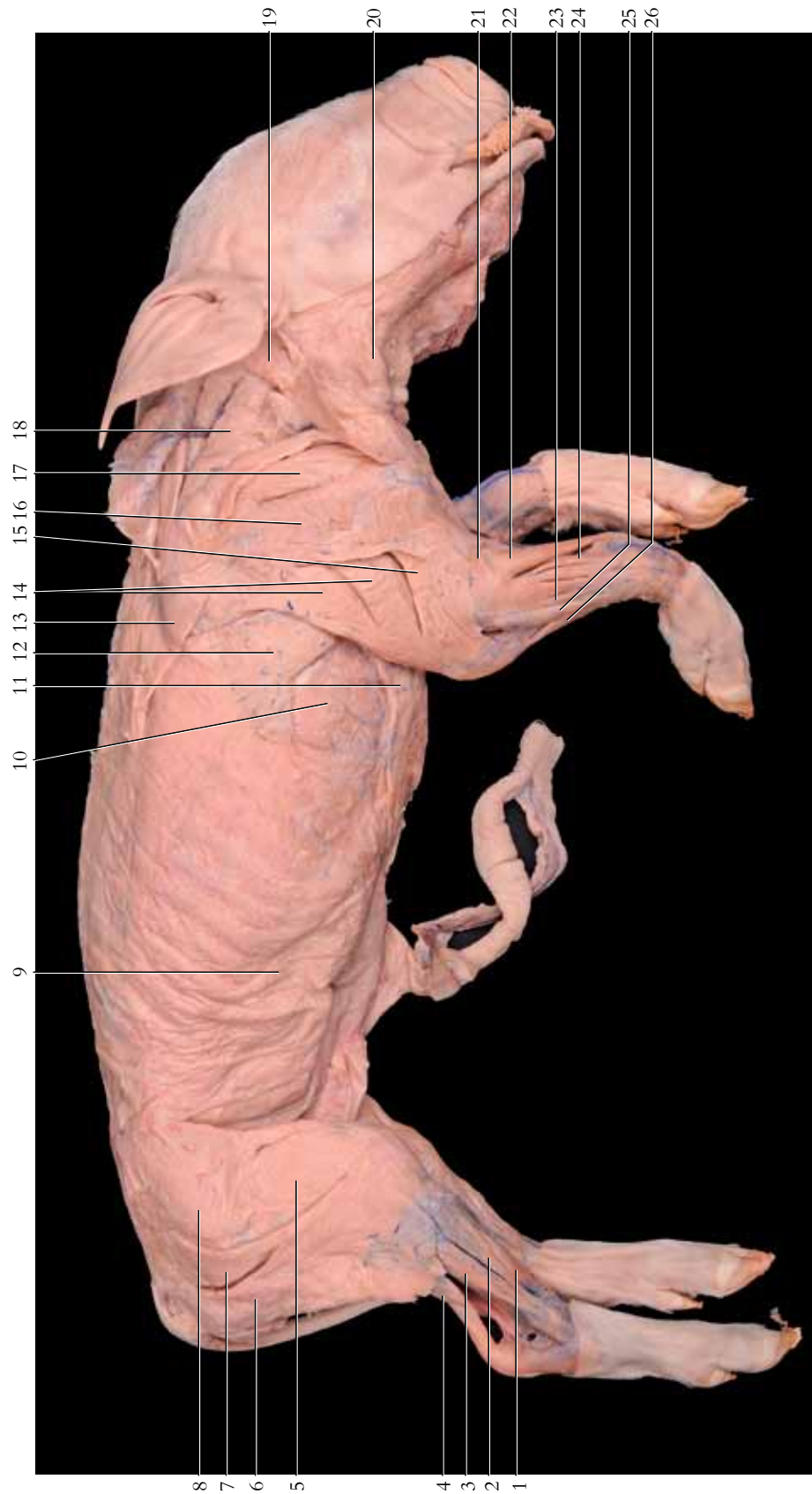
**Figure 20.1** A ventral view of the surface anatomy of the male fetal pig.

- |          |                    |                    |
|----------|--------------------|--------------------|
| 1. Nose  | 5. Scrotum         | 9. Hoof of digit   |
| 2. Wrist | 6. Tail            | 10. Umbilical cord |
| 3. Elbow | 7. Nostril (nares) | 11. Knee           |
| 4. Teats | 8. Tongue          | 12. Ankle          |

- Place your specimen on a dissecting tray ventral side up. Using a sharp scalpel, make a shallow incision through the skin extending from the chin caudally to the umbilical cord. Carefully continue your cut around one side of the umbilical cord. If your specimen is a male, make a diagonal cut from the umbilical cord to the scrotum. If a female, continue a midventral incision from the umbilical cord to the genital papilla. Make an incision around the genitalia and tail.
- From the midventral incision, extend an incision down the medial surfaces of the forelegs to the hoofs and then do the same for the skin of the hind legs. Make circular incisions around each of the hoofs. Following the ventral borders of the lower jaws, make extended cuts from the chin dorsolaterally to just below the ears.
- Grasp the cut edge of the skin and carefully remove it from your specimen. If the skin is difficult to remove, grasp the cut edge of the skin with one hand and push on the muscle with the thumb of the other hand.
- After the specimen is skinned, the muscles can be seen more easily if the moisture on them is sponged away with a paper towel. The muscles of a fetal pig are extremely delicate and as you proceed to dissect your specimen, make certain that you separate the muscles along their natural boundaries. When transection of a muscle is necessary, carefully isolate the muscle from its attached connective tissue and make a clean cut across the belly of the muscle, leaving the origin and insertion intact.
- At the end of the laboratory period, wrap your specimen in muslin cloth and store it in a tight, heavy-duty plastic bag. Discard the skin that was removed from your specimen, and the plastic shipment bag. Wet your specimen from time to time with a preservative solution (usually 2-3% phenol). Caution is necessary when using a phenol wetting solution as it is caustic and poisonous if misused or used in a concentrated form.



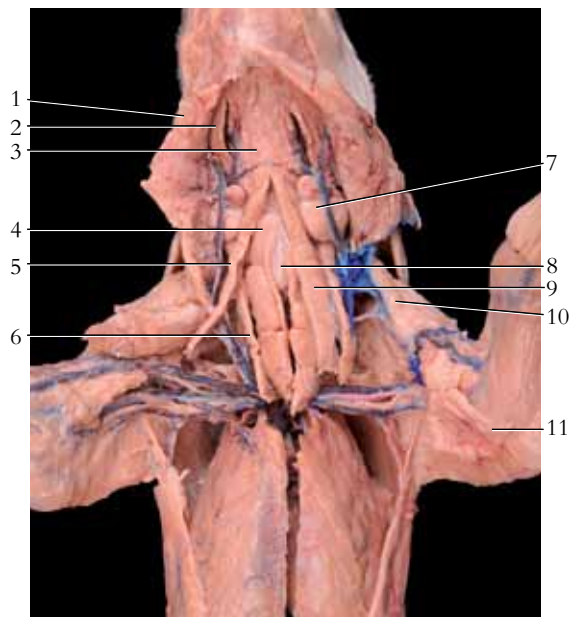




**Figure 20.4** A lateral view of superficial musculature of the fetal pig.

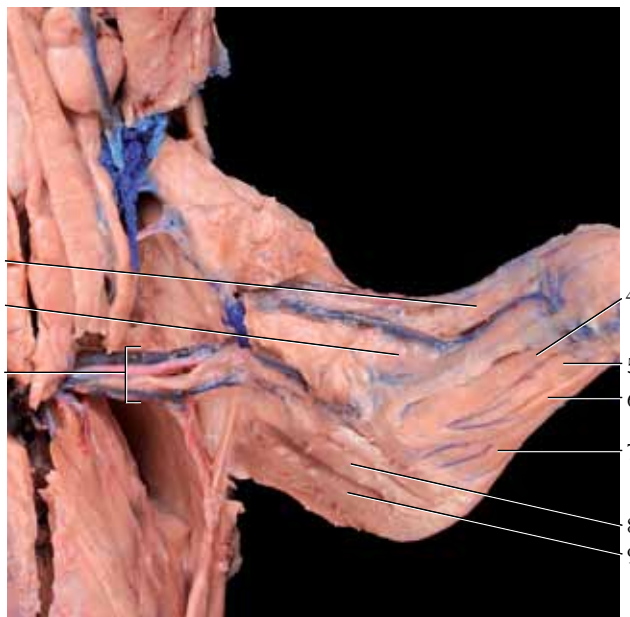
- |                             |                                    |                                       |                                    |
|-----------------------------|------------------------------------|---------------------------------------|------------------------------------|
| 1. Tibialis anterior m.     | 8. Gluteus medius m.               | 15. Triceps brachii m. (lateral head) | 22. Extensor carpi radialis m.     |
| 2. Peroneus tertius m.      | 9. External abdominal oblique m.   | 16. Deltoid m.                        | 23. Extensor digiti m.             |
| 3. Peroneus longus m.       | 10. Serratus ventralis m.          | 17. Supraspinatus m.                  | 24. Extensor digitorum communis m. |
| 4. Gastrocnemius m.         | 11. Pectoralis profundus m.        | 18. Omotransversarius m.              | 25. Ulnaris lateralis m.           |
| 5. Tensor fasciae latae m.  | 12. Latissimus dorsi m.            | 19. Cleidooccipitalis m.              | 26. Flexor digitorum profundus m.  |
| 6. Biceps femoris m.        | 13. Trapezius m.                   | 20. Platysma m.                       |                                    |
| 7. Gluteus superficialis m. | 14. Triceps brachii m. (long head) | 21. Brachialis m.                     |                                    |





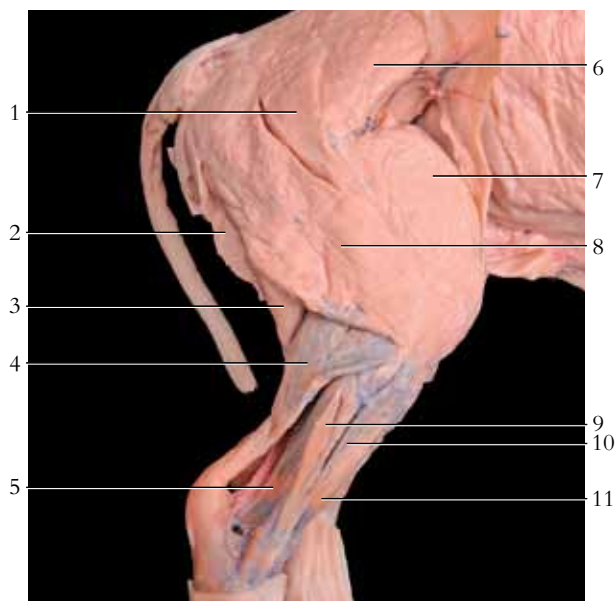
**Figure 20.5** A ventral view of superficial muscles of neck and upper torso.

- |                            |                                 |
|----------------------------|---------------------------------|
| 1. Platysma m. (reflected) | 7. Mandibular gland             |
| 2. Digastric m.            | 8. Larynx                       |
| 3. Mylohyoid m.            | 9. Sternothyroid m.             |
| 4. Sternohyoid m.          | 10. Brachiocephalic m.          |
| 5. Omohyoid m.             | 11. Pectoralis superficialis m. |
| 6. Sternomastoid m.        | (cut and reflected)             |



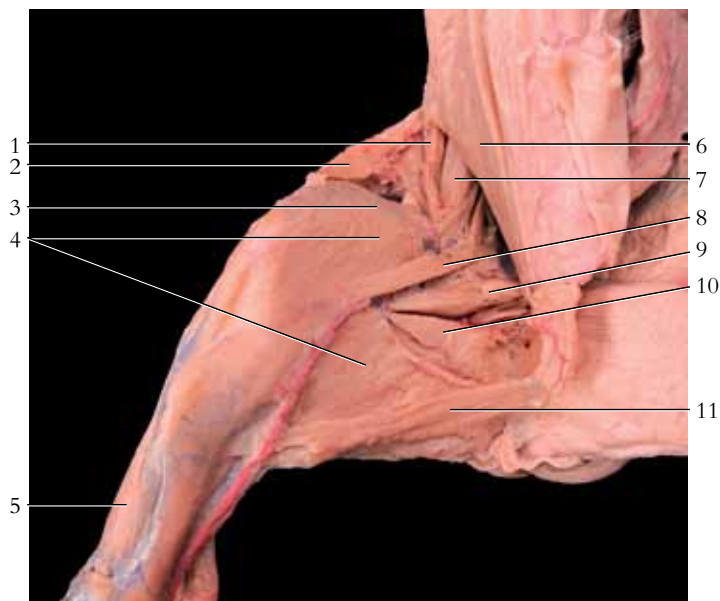
**Figure 20.6** Superficial medial muscles of the forelimb.

- |  |                                      |
|--|--------------------------------------|
| 1. Extensor carpi radialis m.                | 6. Flexor digitorum superficialis m. |
| 2. Biceps brachii m.                         | 7. Flexor carpi ulnaris m.           |
| 3. Axillary artery and vein, brachial plexus | 8. Triceps brachii m. (lateral head) |
| 4. Flexor carpi radialis m.                  | 9. Triceps brachii m. (long head)    |
| 5. Flexor digitorum profundus m.             |                                      |



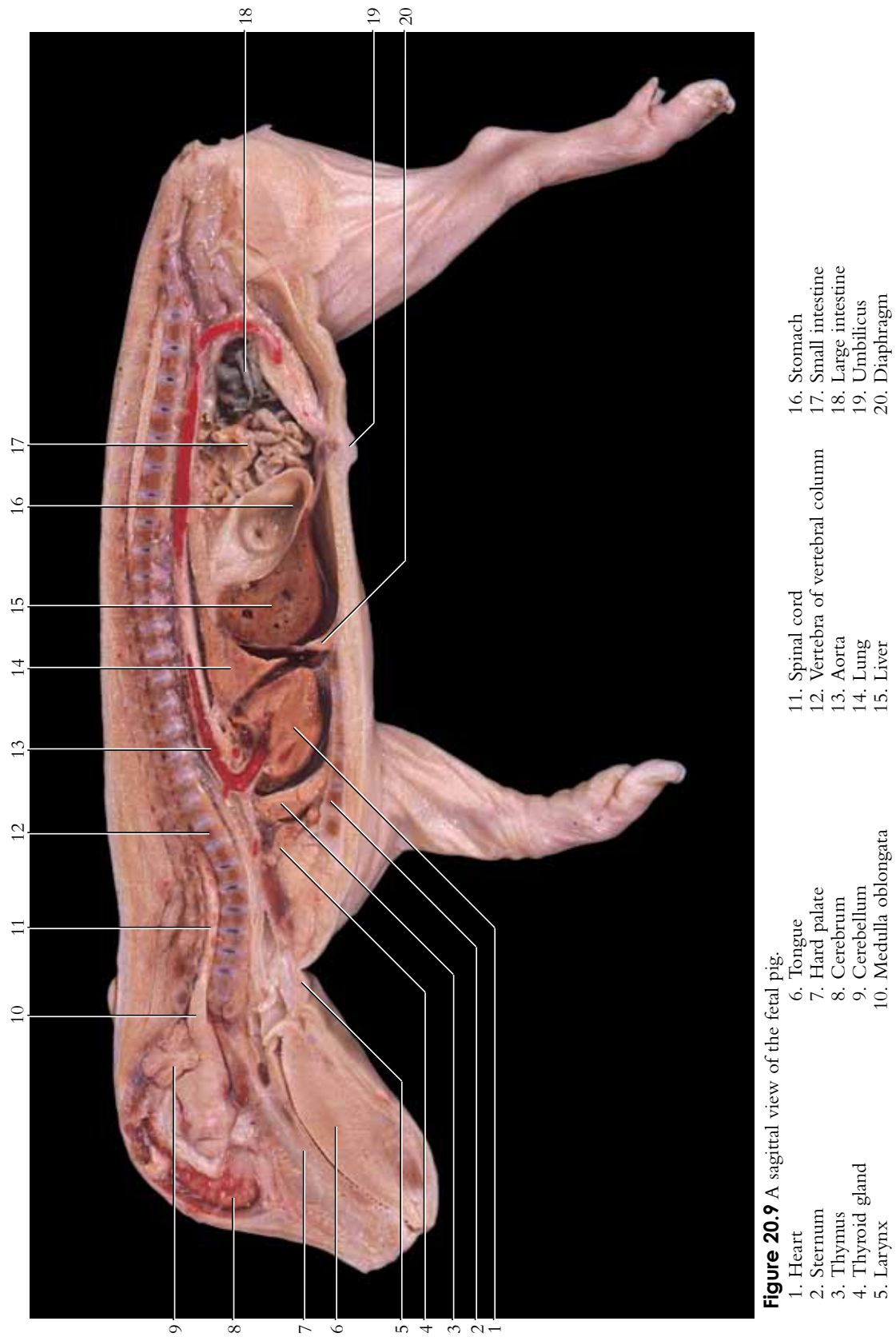
**Figure 20.7** A lateral view of the superficial thigh and leg.

- |   |                                     |
|---|-------------------------------------|
| 1. Gluteus superficialis m.                 | 7. Tensor fasciae latae m.          |
| 2. Semitendinosus m.                        | 8. Biceps femoris m.                |
| 3. Semimembranosus m.                       | 9. Fibularis (peroneus) longus m.   |
| 4. Gastrocnemius m.                         | 10. Fibularis (peroneus) tertius m. |
| 5. Extensor digitorum quarti and quinti mm. | 11. Tibialis anterior m.            |
| 6. Gluteus medius m.                        |                                     |



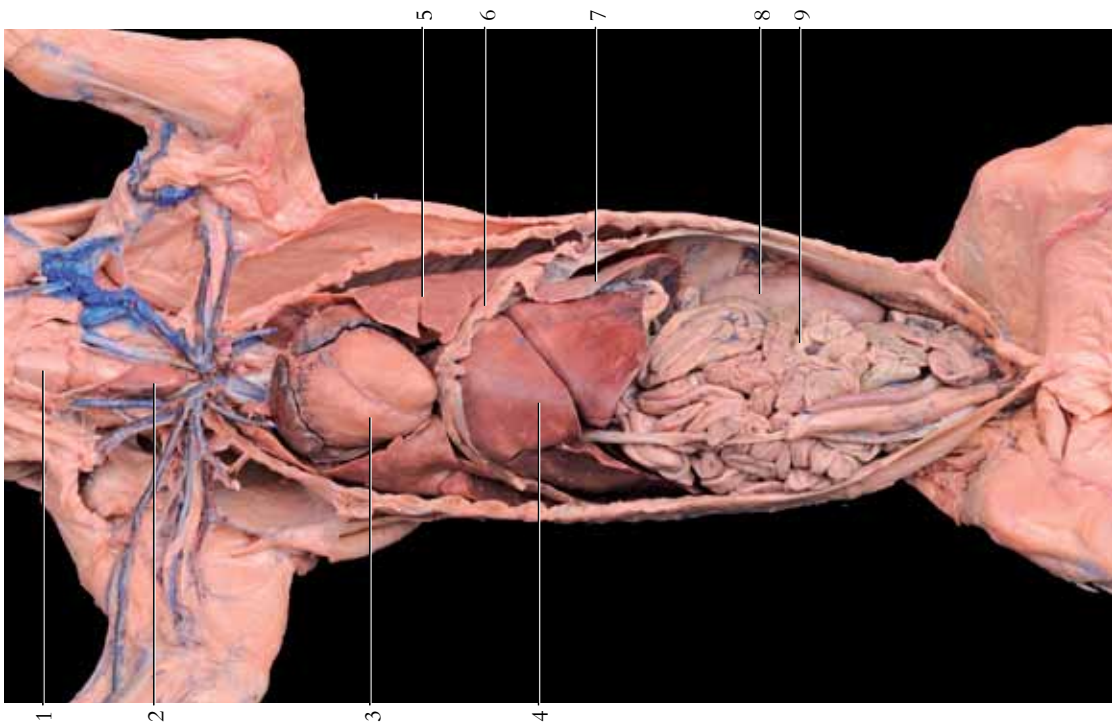
**Figure 20.8** Medial muscles of thigh and leg.

- |                                  |                       |
|----------------------------------|-----------------------|
| 1. Iliacus m.                    | 7. Psoas major m.     |
| 2. Tensor fasciae latae m.       | 8. Sartorius m.       |
| 3. Rectus femoris m.             | 9. Pectineus m.       |
| 4. Semimembranosus m.            | 10. Adductor m.       |
| 5. Tibialis anterior m.          | 11. Semitendinosus m. |
| 6. External abdominal oblique m. |                       |



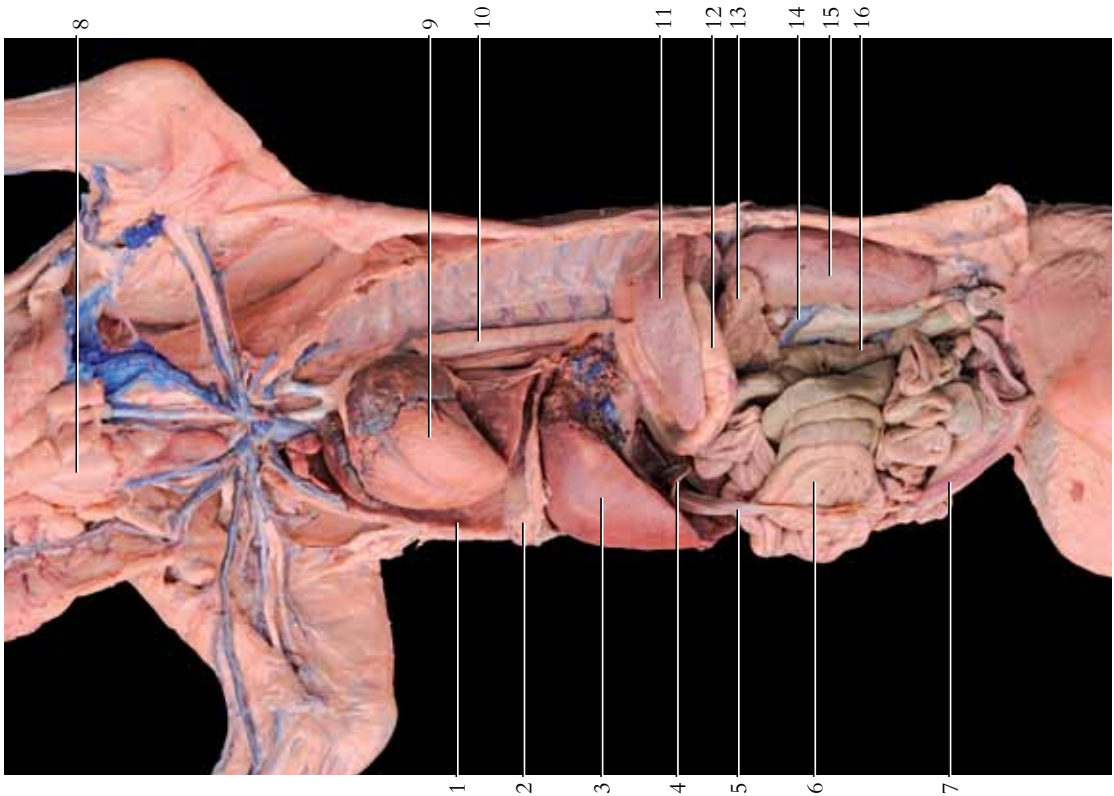
**Figure 20.9** A sagittal view of the fetal pig.





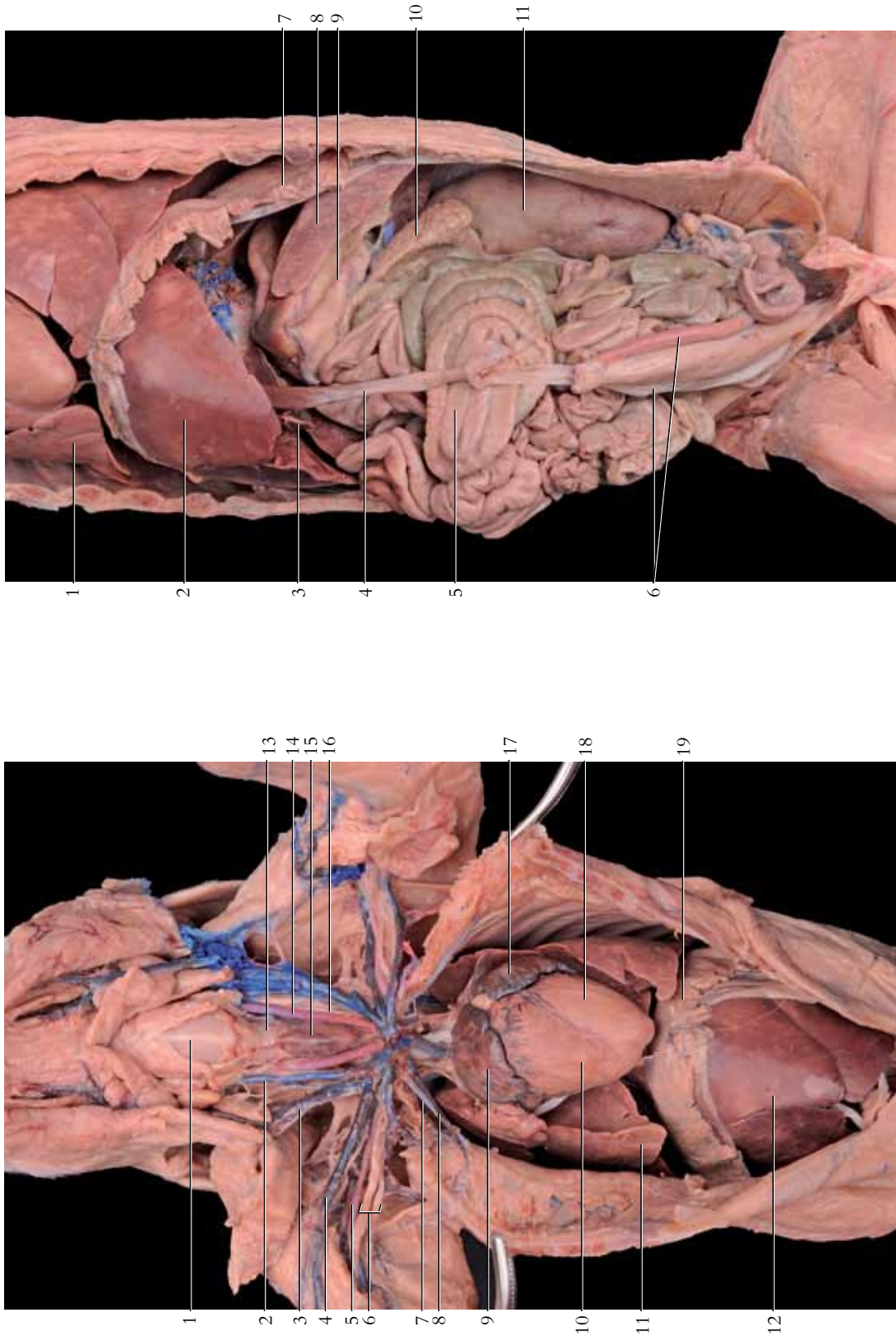
**Figure 20.10** A ventral view of the viscera of a fetal pig.

1. Larynx
2. Thyroid gland
3. Heart
4. Liver
5. Lung
6. Diaphragm
7. Spleen
8. Kidney
9. Small intestine



**Figure 20.11** Deep viscera and associated structures.

1. Lung
2. Diaphragm
3. Liver (cut)
4. Gallbladder
5. Umbilical vein
6. Small intestine
7. Umbilical artery
8. Larynx
9. Heart
10. Thoracic aorta
11. Spleen
12. Stomach
13. Pancreas
14. Renal vein
15. Kidney
16. Colon



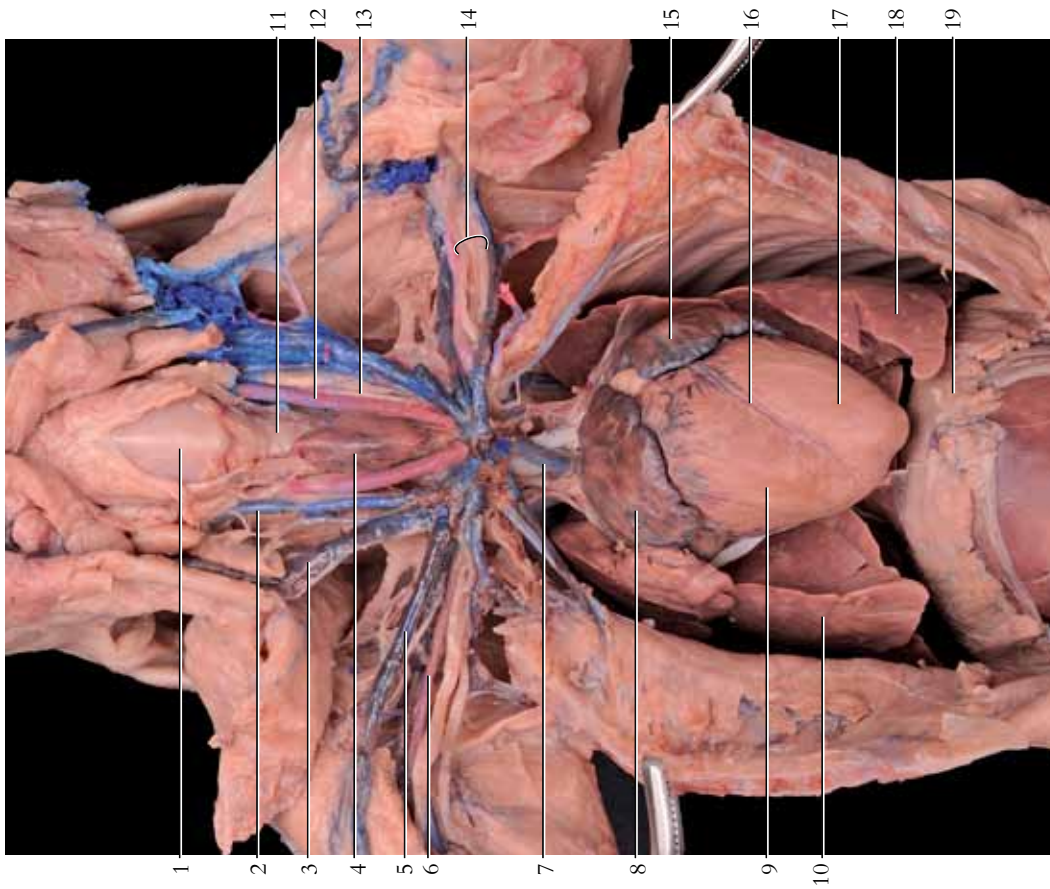
**Figure 20.12** The thorax and neck regions of the fetal pig.

1. Larynx
2. Internal jugular vein
3. External jugular vein
4. Subclavian vein
5. Subclavian artery
6. Brachial plexus
7. Internal thoracic artery
8. Internal thoracic vein
9. Right auricle
10. Right ventricle
11. Lung
12. Liver
13. Trachea
14. Left common carotid artery
15. Thyroid gland
16. Vagus nerve
17. Left auricle
18. Left ventricle
19. Diaphragm

**Figure 20.13** The abdominal organs of the fetal pig.

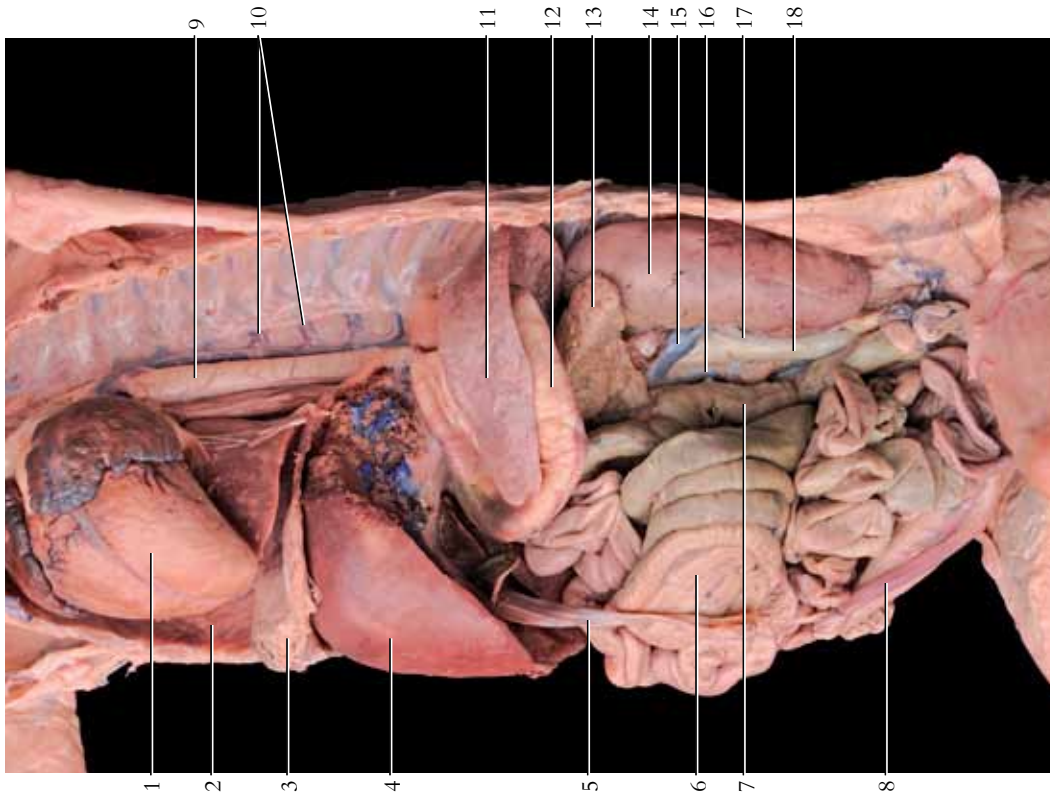
1. Lung
2. Liver (cut)
3. Gallbladder
4. Umbilical vein
5. Small intestine
6. Umbilical arteries
7. Diaphragm
8. Spleen
9. Stomach
10. Pancreas
11. Kidney





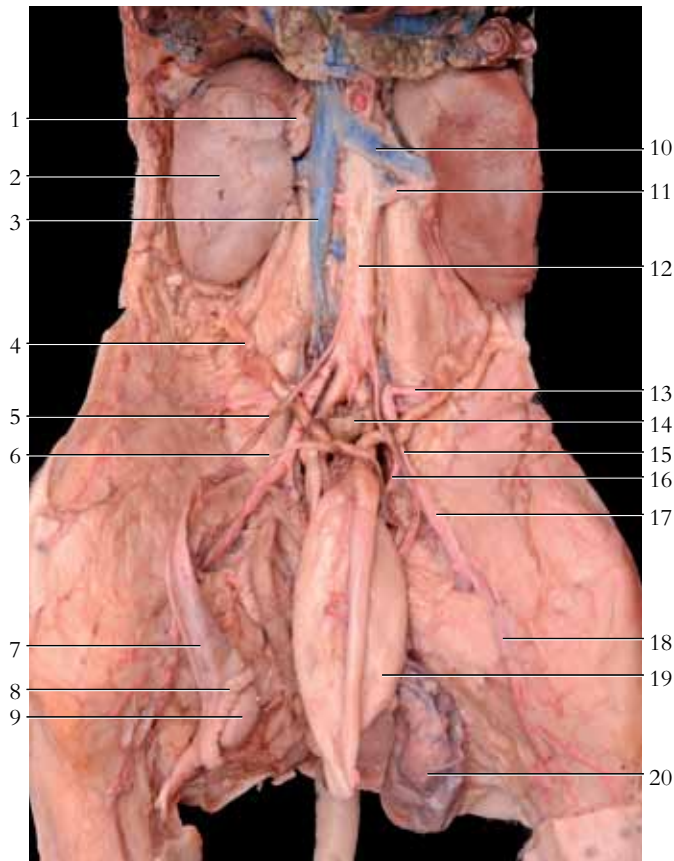
**Figure 20.14** The arteries and veins of the neck and thoracic region.

- |                                 |                                |
|---------------------------------|--------------------------------|
| 1. Larynx                       | 11. Trachea                    |
| 2. Internal jugular vein        | 12. Left common carotid artery |
| 3. External jugular vein        | 13. Vagus nerve                |
| 4. Thyroid gland                | 14. Brachial plexus            |
| 5. Subclavian artery            | 15. Left auricle               |
| 6. Subclavian vein              | 16. Coronary vessels           |
| 7. Cranial (superior) vena cava | 17. Left ventricle             |
| 8. Right auricle                | 18. Left lung                  |
| 9. Right ventricle              | 19. Diaphragm                  |
| 10. Right lung                  |                                |



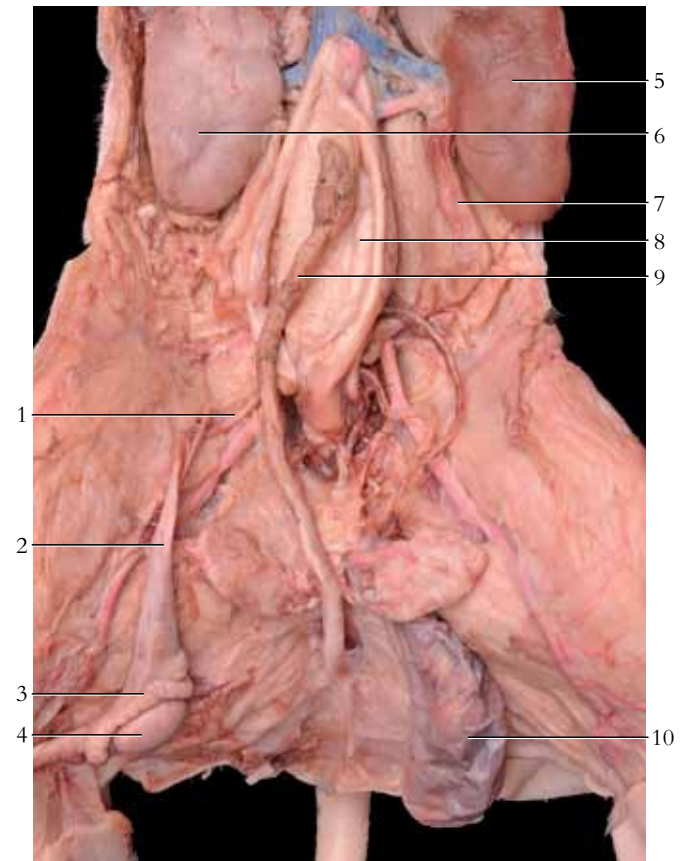
**Figure 20.15** Structures of the abdomen and lower extremities.

- |                     |                                  |
|---------------------|----------------------------------|
| 1. Heart            | 10. Internal intercostal vessels |
| 2. Lung             | 11. Spleen                       |
| 3. Diaphragm        | 12. Stomach                      |
| 4. Liver            | 13. Pancreas                     |
| 5. Umbilical vein   | 14. Kidney                       |
| 6. Small intestine  | 15. Renal vein                   |
| 7. Colon            | 16. Caudal (inferior) vena cava  |
| 8. Umbilical artery | 17. Renal artery                 |
| 9. Thoracic aorta   | 18. Abdominal aorta              |



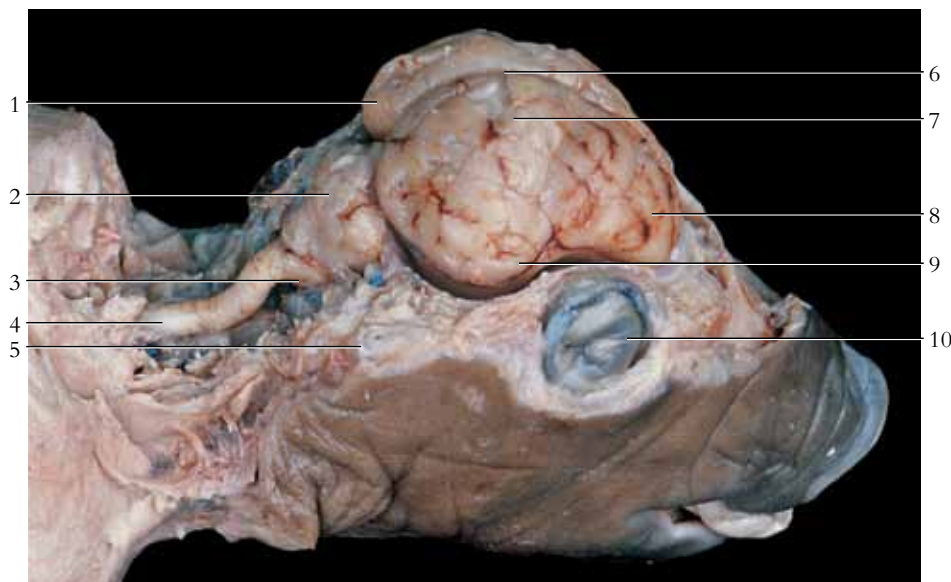
**Figure 20.16** The urogenital system of the fetal pig.

- |                                |                           |
|--------------------------------|---------------------------|
| 1. Adrenal gland               | 11. Renal artery          |
| 2. Right kidney                | 12. Descending aorta      |
| 3. Caudal (inferior) vena cava | 13. Iliolumbar artery     |
| 4. Ureter                      | 14. Rectum (cut)          |
| 5. Genital vessels             | 15. Common iliac artery   |
| 6. Vas (ductus) deferens       | 16. Internal iliac artery |
| 7. Spermatic cord              | 17. External iliac artery |
| 8. Epididymis                  | 18. Femoral artery        |
| 9. Testis                      | 19. Urinary bladder       |
| 10. Renal vein                 | 20. Testis                |



**Figure 20.17** The urogenital system of the fetal pig.

- |                          |                    |
|--------------------------|--------------------|
| 1. Vas (ductus) deferens | 6. Right kidney    |
| 2. Spermatic cord        | 7. Ureter          |
| 3. Epididymis            | 8. Urinary bladder |
| 4. Right testis          | 9. Penis           |
| 5. Left kidney           | 10. Left testis    |



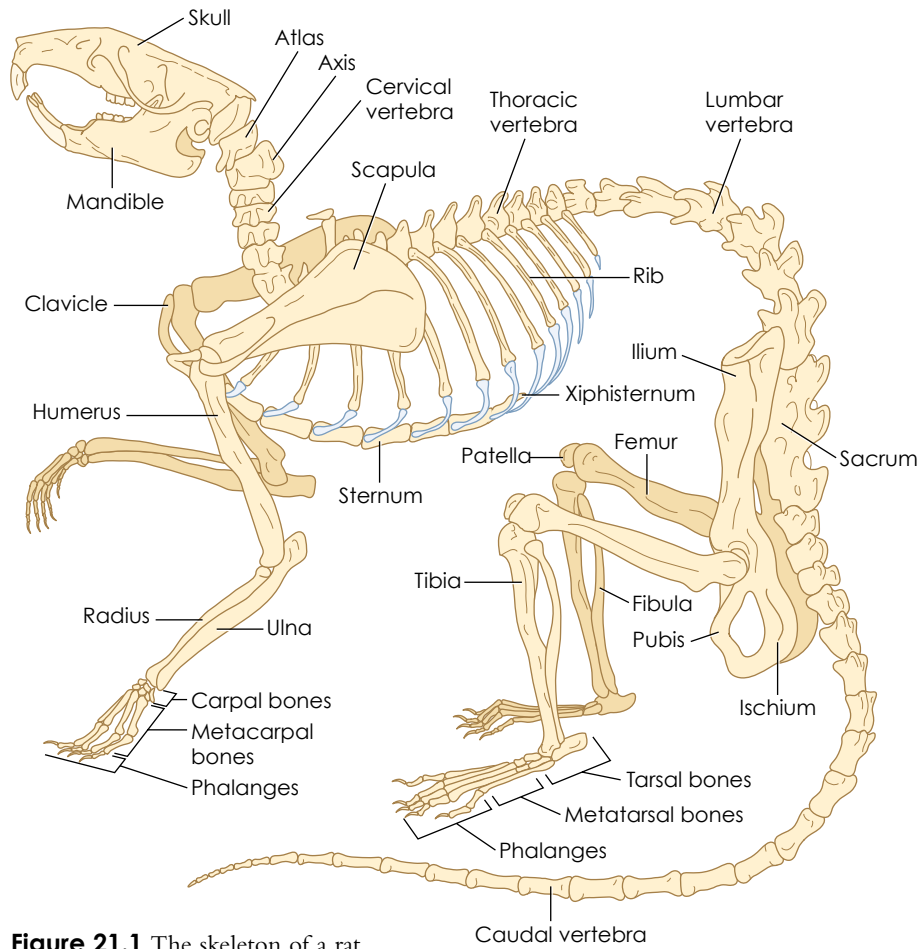
**Figure 20.18** The general structures of the fetal pig brain. Because the cerebrum is less defined in pigs, the regions are not known as lobes as they are in humans.

- |                                 |
|---------------------------------|
| 1. Occipital region of cerebrum |
| 2. Cerebellum                   |
| 3. Medulla oblongata            |
| 4. Spinal cord                  |
| 5. External acoustic meatus     |
| 6. Longitudinal fissure         |
| 7. Parietal region of cerebrum  |
| 8. Frontal region of cerebrum   |
| 9. Temporal region of cerebrum  |
| 10. Eye                         |



# Chapter 21

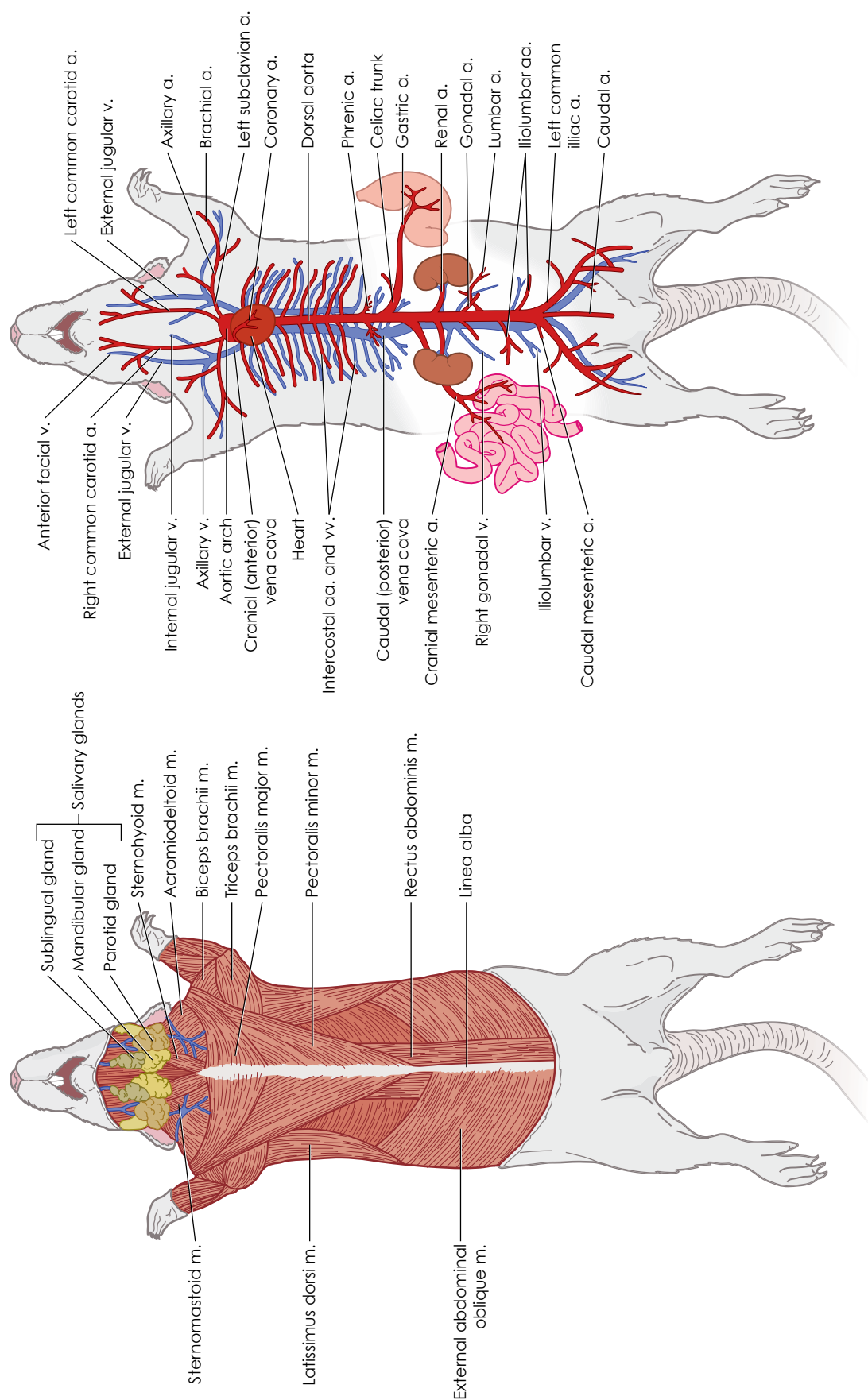
## Rat Dissection



**Figure 21.1** The skeleton of a rat.



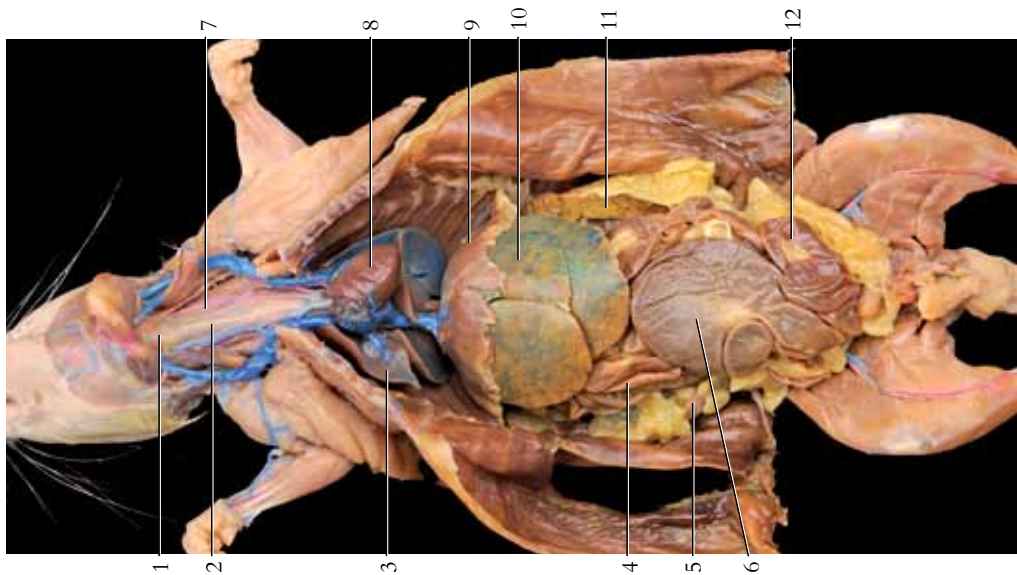
**Figure 21.2** The laboratory white rat is a captive-raised rodent that is commercially available for biological and medical experiments and research. White rats are also embalmed and available as dissection specimens in biology, vertebrate biology, and general zoology laboratories.



**Figure 21.3** A ventral view of the rat musculature (m. = muscle).

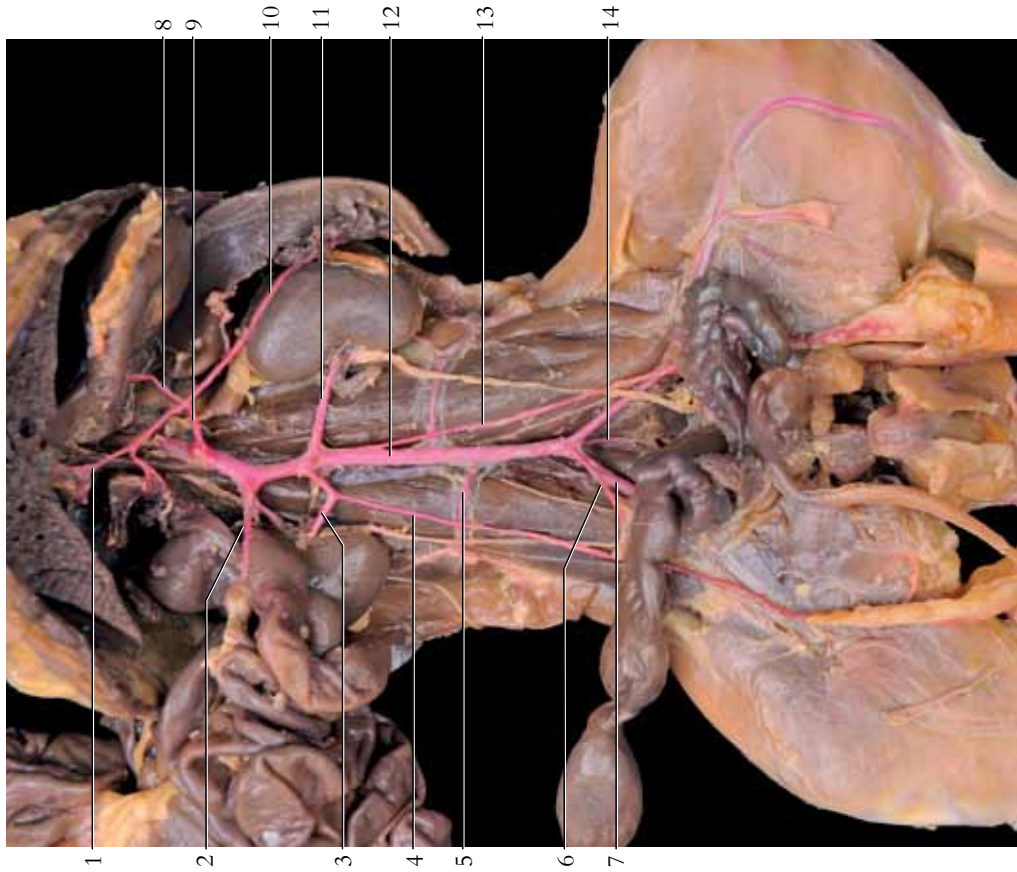
**Figure 21.4** The circulatory system of a rat. The arteries are colored red (a. = artery, aa. = arteries; v. = vein, vv. = veins).





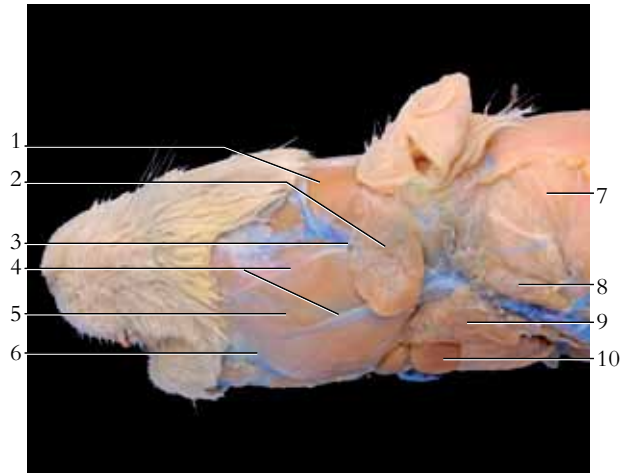
**Figure 21.5** A ventral view of the rat viscera.

1. Larynx
2. Trachea
3. Right lung
4. Jejunum
5. Right ovary
6. Cecum
7. Esophagus
8. Heart
9. Diaphragm
10. Liver
11. Spleen
12. Ileum



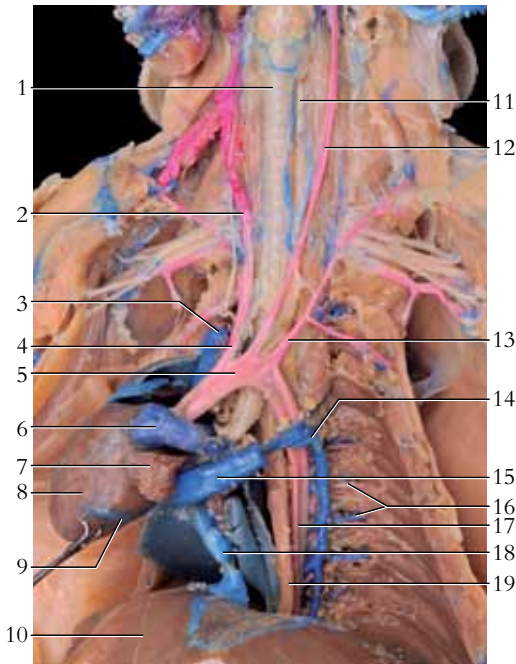
**Figure 21.6** The abdominal arteries of the rat.

1. Hepatic artery
2. Right renal artery
3. Cranial mesenteric artery
4. Right testicular artery
5. Right ilio-lumbar artery
6. Caudal mesenteric artery (cut)
7. Right common iliac artery
8. Gastric artery
9. Celiac trunk
10. Splenic artery
11. Left renal artery
12. Abdominal aorta
13. Left testicular artery
14. Middle sacral artery



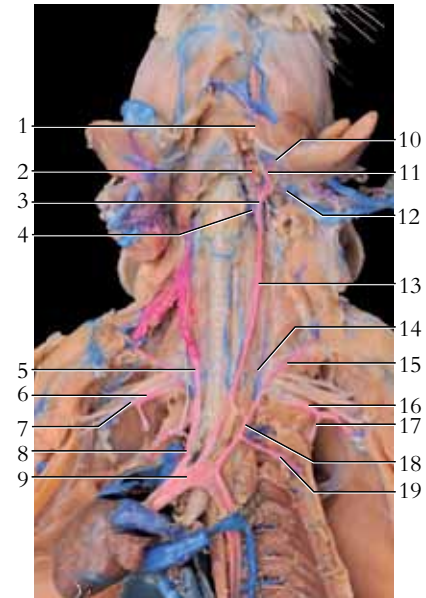
**Figure 21.7** The head and neck region of the rat.

- |                                |                           |
|--------------------------------|---------------------------|
| 1. Temporalis m.               | 6. Parotid duct           |
| 2. Extraorbital lacrimal gland | 7. Cervical trapezius m.  |
| 3. Extraorbital lacrimal duct  | 8. Parotid gland          |
| 4. Facial nerve                | 9. Mandibular gland       |
| 5. Masseter m.                 | 10. Mandibular lymph node |



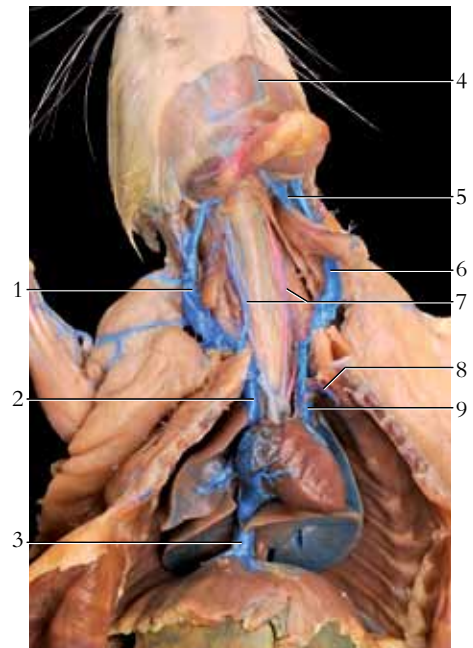
**Figure 21.9** The rat heart (reflected) showing the major veins and arteries.

- |                                  |                                 |
|----------------------------------|---------------------------------|
| 1. Trachea                       | 10. Diaphragm                   |
| 2. Right common carotid artery   | 11. Esophagus                   |
| 3. Right cranial vena cava (cut) | 12. Left common carotid artery  |
| 4. Brachiocephalic trunk         | 13. Left subclavian artery      |
| 5. Aortic arch                   | 14. Azygos vein                 |
| 6. Pulmonary trunk               | 15. Coronary sinus (cut)        |
| 7. Left auricle                  | 16. Intercostal artery and vein |
| 8. Left ventricle                | 17. Aorta                       |
| 9. Coronary vein                 | 18. Caudal vena cava            |
|                                  | 19. Esophagus                   |



**Figure 21.8** The arteries of the thoracic and neck regions of the rat.

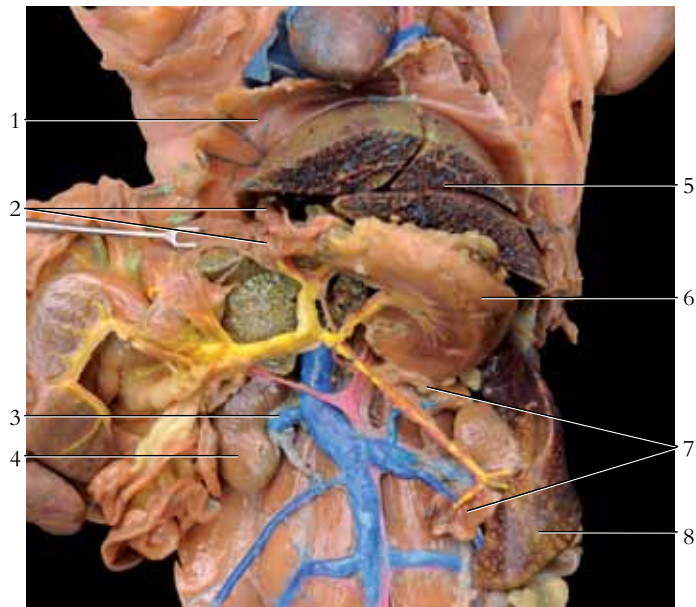
- |                                |                                |
|--------------------------------|--------------------------------|
| 1. Facial artery               | 11. Internal carotid artery    |
| 2. Lingual artery              | 12. Occipital artery           |
| 3. External carotid artery     | 13. Left common carotid artery |
| 4. Cranial thyroid artery      | 14. Vertebral artery           |
| 5. Right common carotid artery | 15. Cervical trunk             |
| 6. Right axillary artery       | 16. Lateral thoracic artery    |
| 7. Right brachial artery       | 17. Left axillary artery       |
| 8. Brachiocephalic artery      | 18. Left subclavian artery     |
| 9. Aortic arch                 | 19. Internal thoracic artery   |
| 10. External maxillary artery  |                                |



**Figure 21.10** The veins of the thoracic and neck regions of the rat.

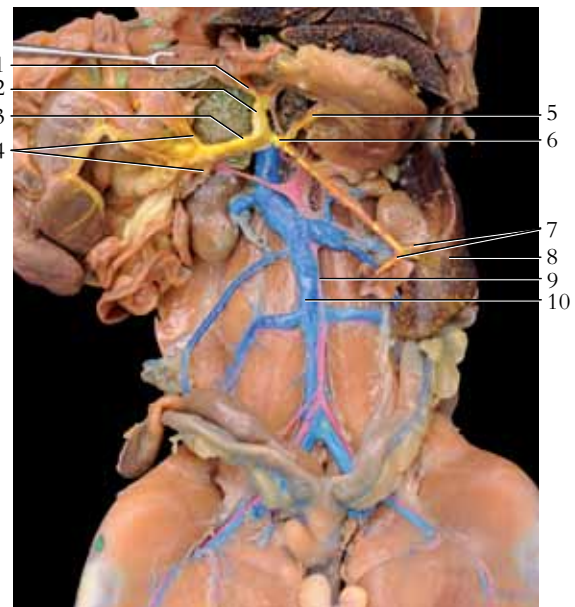
- |                            |                           |
|----------------------------|---------------------------|
| 1. Cephalic vein           | 6. External jugular vein  |
| 2. Right cranial vena cava | 7. Internal jugular vein  |
| 3. Caudal vena cava        | 8. Lateral thoracic vein  |
| 4. Linguofacial vein       | 9. Left cranial vena cava |
| 5. Maxillary vein          |                           |





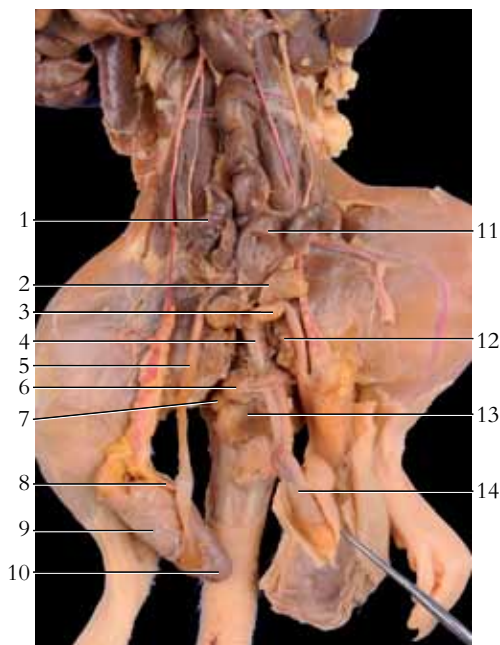
**Figure 21.11** The abdominal viscera and vessels of the rat.

- |   |                                   |
|---|-----------------------------------|
| 1. Diaphragm                              | 5. Liver (cut)                    |
| 2. Biliary and duodenal parts of pancreas | 6. Stomach                        |
| 3. Right renal vein                       | 7. Gastrosplenic part of pancreas |
| 4. Right kidney                           | 8. Spleen                         |



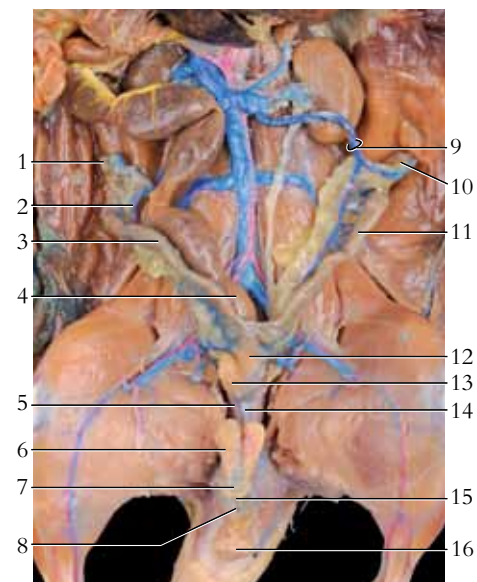
**Figure 21.12** The branches of the hepatic portal system.

- |                                     |                       |
|-------------------------------------|-----------------------|
| 1. Cranial pancreaticoduodenal vein | 6. Gastrosplenic vein |
| 2. Hepatic portal vein              | 7. Splenic branches   |
| 3. Cranial mesenteric vein          | 8. Spleen             |
| 4. Intestinal branches              | 9. Abdominal aorta    |
| 5. Gastric vein                     | 10. Caudal vena cava  |



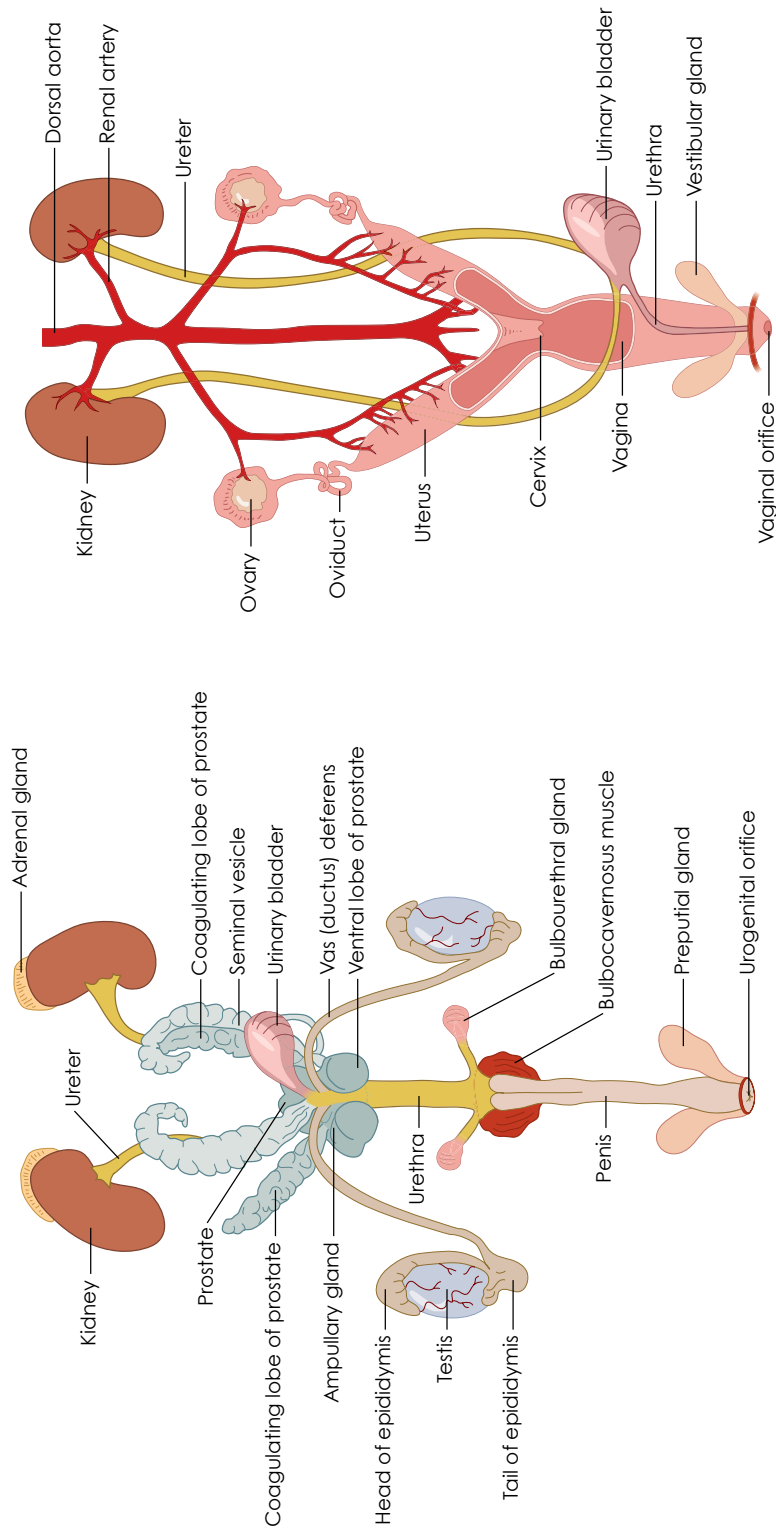
**Figure 21.13** The urogenital system of the male rat.

- |                                 |   |
|---------------------------------|---|
| 1. Vesicular gland              | 9. Testis                                       |
| 2. Prostate (ventral part)      | 10. Tail of epididymis                          |
| 3. Prostate (dorsolateral part) | 11. Urinary bladder                             |
| 4. Urethra in the pelvic canal  | 12. Symphysis pubis (cut exposing pelvic canal) |
| 5. Vas (ductus) deferens        | 13. Bulbocavernosus muscle                      |
| 6. Crus of penis                | 14. Penis                                       |
| 7. Bulbourethral gland          |   |
| 8. Head of epididymis           |   |



**Figure 21.14** The urogenital system of the female rat.

- |                            |                            |
|----------------------------|----------------------------|
| 1. Ovary                   | 9. Uterine artery and vein |
| 2. Uterine artery and vein | 10. Ovary                  |
| 3. Uterine horn            | 11. Uterine horn           |
| 4. Colon                   | 12. Uterine body           |
| 5. Vagina                  | 13. Urinary bladder        |
| 6. Preputial gland         | 14. Urethra                |
| 7. Clitoris                | 15. Urethral opening       |
| 8. Vaginal opening         | 16. Anus                   |



**Figure 21.15** The urogenital organs of a male rat.

**Figure 21.16** The urogenital organs of a female rat.



# Glossary of Prefixes & Suffixes

| Element  | Definition and Example                           | Element  | Definition and Example                          | Element  | Definition and Example                         |
|----------|--|----------|---|----------|--|
| a-       | absent, deficient or without: atrophy            |          | space or cavity: blastocoele                    | entero-  | intestine: enteritis                           |
| ab-      | off, away from: abduct                           | cephal-  | head: cephalis                                  | epi-     | upon, in addition: epidermis                   |
| abdomin- | abdomen  | cerebro- | brain: cerebrospinal fluid                      | erythro- | red: erythrocyte                               |
| -able    | capable of: viable                               | chol-    | bile: cholic                                    | ex-      | out of: excise                                 |
| ac-      | toward, to: actin                                | chondr-  | cartilage: chondrocyte                          | exo-     | outside: exocrine                              |
| acou-    | hear: acoustic                                   | chrom-   | color: chromocyte                               | extra-   | outside of, beyond, in addition: extracellular |
| ad-      | denoting to, toward: adduct                      | -cid(e)  | destroy: germicide                              |          |  |
| af-      | movement toward a central point: afferent artery | circum-  | around: circumduct                              | fasci-   | band: fascia                                   |
|          |  | -cis     | cut, kill: excision                             | febr-    | fever: febrile                                 |
| alba-    | pale or white: linea alba                        | co-      | together: copulation                            | -ferent  | bear, carry: efferent arteriole                |
| -alg     | pain: neuralgia                                  | coel-    | hollow cavity: coelom                           | fiss-    | split: fissure                                 |
| ambi-    | both: ambidextrous                               | con-     | with, together: congenital                      | for-     | opening: foramen                               |
| angi-    | pertaining to vessel: angiology                  | contra-  | against, opposite: contraception                | -form    | shape: fusiform                                |
| ante-    | before: antebrachium                             | corn-    | denoting hardness: cornified                    |          |  |
| anti-    | against: anticoagulant                           | corp-    | body: corpus                                    | gastro-  | stomach: gastrointestinal                      |
| aqua-    | water: aqueous                                   | crypt-   | hidden: cryptorchism                            | -gen     | an agent that produces or originates: pathogen |
| archi-   | to be first: archeteron                          | cyan-    | blue color: cyanosis                            | -genic   | produced from, producing: carcinogenic         |
| arthri-  | joint: arthritis                                 | cysti-   | sac or bladder: cystoscope                      | gloss-   | tongue: glossopharyngeal                       |
| -asis    | condition or state of: homeostasis               | cyto-    | cell: cytology                                  | glyco-   | sugar: glycosuria                              |
| aud-     | pertaining to ear: auditory                      | de-      | down, from: descent                             | -gram    | a record, recording: myogram                   |
| auto-    | self: autolysis                                  | derm-    | skin: dermatology                               | gran-    | grain, particle: agranulocyte                  |
|          |  | di-      | two: diarthrotic                                | -graph   | instrument for recording: electrocardiograph   |
| bi-      | two: bipedal                                     | dipl-    | double: diploid                                 | grav-    | heavy: gravid                                  |
| bio-     | life: biology                                    | dis-     | apart, away from: disarticulate                 | gyn-     | female sex: gynecology                         |
| blast-   | generative or germ bud: osteoblast               | duct-    | lead, conduct: ductus deferens                  |          |  |
| brachi-  | arm: brachialis                                  | dur-     | hard: dura mater                                | hema(o)- | blood: hematology                              |
| brachy-  | short: brachydont                                | -dynia   | pain:   | haplo-   | simple or single: haploid                      |
| brady-   | slow: bradycardia                                | dys-     | bad, difficult, painful: dysentery              | hemi-    | half: hemiplegia                               |
| bucc-    | cheek: buccal cavity                             |          |   | hepat-   | liver: hepatic portal                          |
|          |  |          |   | hetero-  | other, different: heterosexual                 |
| cac-     | bad, ill: cachexia                               | e-       | out, from: eccrine                              | histo-   | tissue: histology                              |
| calci-   | stone: calculus                                  | ecto-    | outside, outer, external: ectoderm              | holo-    | whole, entire: holocrine                       |
| capit-   | head: capitis                                    | -ectomy  | surgical removal: tonsillectomy                 | homo-    | same, alike: homologous                        |
| carcin-  | cancer: carcinogenic                             | ede-     | swelling: edema                                 | hydro-   | water: hydrocoel                               |
| cardi-   | heart: cardiac                                   | -emia    | pertaining to a condition of the blood: lipemia | hyper-   | beyond, above, excessive: hypertension         |
| caud-    | tail: cauda equina                               |          |   | hypo-    | under, below: hypoglycemia                     |
| cata-    | lower, under, against: catabolism                | end-     | within: endoderm                                |          |  |
| -coel    | swelling, and enlarged                           |          |   |          |  |



| Element  | Definition and Example               | Element   | Definition and Example                            | Element  | Definition and Example                            |
|----------|--------------------------------------|-----------|---|----------|---|
| -ia      | state or condition: hypoglycemia     | noto-     | back: notochord                                   | -poieis  | formation of: hemato-poiesis                      |
| -iatrics | medical specialties: pediatrics      | ob-       | against, toward, in front of: obturator           | poly-    | many, much: polyploid                             |
| idio-    | self, separate, distinct: idiopathic | oc-       | against: occlusion                                | post-    | after, behind: postnatal                          |
| ilio-    | ilium: iliosacral                    | -oid      | resembling, likeness: sigmoid                     | pre-     | before in time or place: prenatal                 |
| infra-   | beneath: infraspinal                 | oligo-    | few, small: oligodendrocyte                       | prim-    | first: primitive                                  |
| inter-   | among, between:                      | -oma      | tumor: lymphoma                                   | pro-     | before in time or place: prosect                  |
| intra-   | inside, within: intracellular        | oo-       | egg: oocyte                                       | proct-   | anus: proctology                                  |
| -ion     | process: acromion                    | or-       | mouth: oral                                       | pseudo-  | false: pseudostratified                           |
| iso-     | equal, like: isotonic                | orchi-    | testicles: cryptorchidism                         | psycho-  | mental: psychology                                |
| -ism     | condition or state: rheumatism       | -ory      | pertaining to: sensory                            | pyo-     | pus: pyoculture                                   |
| -itis    | inflammation: meningitis             | osteo-    | bone: osteoblast                                  | quad-    | fourfold: quadriceps femoris                      |
| labi-    | lip: labium majus                    | -ose      | full of: adipose                                  | re-      | back, again: repolarization                       |
| lacri-   | tears: nasolacrimal                  | oto       | ear: otolith                                      | rect-    | straight: rectus abdominis                        |
| later-   | side: lateral                        | ovo-      | egg: ovum   | reno-    | kidney: renal                                     |
| -logy    | science of: morphology               | para-     | give birth to, bear: parturition                  | rete-    | network: retina                                   |
| -lysis   | solution, dissolve: hemolysis        | para-     | near, beyond, beside: paranasal                   | retro-   | backward: retroperitoneal                         |
| macro-   | large, great: macrophage             | path-     | disease, that which undergoes sickness: pathology | rhin-    | nose: rhinitis                                    |
| mal-     | bad, abnormal, disorder: malignant   | -pathy    | abnormality, disease: neuropathy                  | -rrhage  | excessive flow: hemorrhage                        |
| medi-    | middle: medial                       | ped-      | children: pediatrician                            | -rrhea   | flow, or discharge: diarrhea                      |
| mega-    | great, large: megakaryocyte          | pen-      | need, lack: penicillin                            | sanguin- | blood: sanguiferous                               |
| meso-    | middle or moderate: mesoderm         | -penia    | deficiency: thrombocytopenia                      | sarc-    | flesh: sarcoplasm                                 |
| meta-    | after, beyond: metatarsal            | per-      | through: percutaneous                             | -scope   | instrument for examination of a part: stethoscope |
| micro-   | small: microtome                     | peri-     | near, around: pericardium                         | -sect    | cut: dissect                                      |
| mito-    | thread: mitosis                      | phag-     | to eat: phagocyte                                 | semi-    | half: semilunar                                   |
| mono-    | alone, one, single: monocyte         | -phil     | have an affinity for: neutrophil                  | serrate- | saw-edged: serratus anterior                      |
| mons-    | mountain: mons pubis                 | phlebo-   | vein: phlebitis                                   | -sis     | state or condition: dialysis                      |
| morph-   | form, shape: morphology              | -phobe    | abnormal fear, dread: hydrophobia                 | steno-   | narrow: stenohaline                               |
| multi-   | many, much: multinuclear             | -plasty   | reconstruction of: rhinoplasty                    | -stomy   | surgical opening: tracheotomy                     |
| myo-     | muscle: myology                      | platy-    | flat, side: platysma                              | sub-     | under, beneath, below: subcutaneous               |
| narc-    | numbness, stupor: narcotic           | -plegia   | stroke, paralysis: paraplegia                     | super-   | above, beyond, upper: superficial                 |
| neo-     | new, young: neonatal                 | -pnea     | to breathe: apnea                                 | supra-   | above, over: suprarenal                           |
| necro-   | corpse, dead: necrosis               | pneumato- | breathing: pneumonia                              |          |   |
| nephro-  | kidney: nephritis                    | pod-      | foot: podiatry                                    |          |   |
| neuro-   | nerve: neurolemma                    |           |   |          |   |





| Element   | Definition and Example                        |
|-----------|---|
| syn (sym) | together, joined, with:<br>synapse            |
| tachy-    | swift, rapid: tachometer                      |
| tele-     | far: telencephalon                            |
| tens-     | stretch: tensor fascia lata                   |
| tetra-    | four: tetrad                                  |
| therm-    | heat: thermogram                              |
| thorac-   | chest: thoracic cavity                        |
| thrombo-  | lump, clot: thrombocyte                       |
| -tomy     | cut: appendectomy                             |
| tox-      | poison: toxic                                 |
| tract-    | draw, drag: traction                          |
| trans-    | across, over: transfuse                       |
| tri-      | three: trigone                                |
| trich-    | hair: trichology                              |
| -trophy   | a state relating to<br>nutrition: hypertrophy |
| -tropic   | turning toward,<br>changing: gonadotropic     |
| ultra-    | beyond, excess:<br>ultrasonic                 |
| uni-      | one: unicellular                              |
| uro-      | urine, urinary organs or<br>tract: uroscope   |
| -uria     | urine: polyuria                               |
| vas-      | vessel: vasoconstriction                      |
| vermi-    | worm: vermiform                               |
| viscer-   | organ: visceral                               |
| vit-      | life: vitamin                                 |
| zoo-      | animal: zoology                               |
| zygo-     | union, join: zygote                           |

## A

**abdomen** (ab-do'men): the portion of the trunk located between the diaphragm and the pelvis; contains the abdominal cavity and its visceral organs.

**abduction** (ab-duk'shun): a movement away from the axis or midline of the body; opposite of adduction; a movement of a digit away from the axis of a limb.

**acapnia** (ah-kap'ne-ah): a decrease in normal amount of CO<sub>2</sub> in the blood.

**accommodation** (ah-kom-o-da'shun): a change in the shape of the lens of the eye so that vision is more acute; the focusing for various distances.

**acetone** (as'e-tone): an organic compound that may be present in the urine of diabetics; also called ketone bodies.

**Achilles tendon** (ah-kil'ez): see *tendo calcaneus*.

**acidosis** (as-i-do'sis): a disorder of body chemistry in which the alkaline substances of the blood are reduced below normal.

**actin** (ak'tin): a protein in muscle fibers that together with myosin is responsible for contraction.

**acoustic** (ah-koos'tik): referring to sound or the sense of hearing.

**adduction** (ah-duk'shun): a movement toward the axis or midline of the body; opposite of abduction; a movement of a digit toward the axis of a limb.

**adenohypophysis** (ad'e-no-hi-pof'i-sis): anterior pituitary gland.

**adenoid** (ad'e-noid): paired lymphoid structures in the nasopharynx; also called pharyngeal tonsils.

**adenosine triphosphate (ATP)** (ah-den'o-sen tri-fos'fate): a chemical compound that provides energy for cellular use.

**adipose** (ad'e-pose): fat, or fat-containing, such as adipose tissue.

**adrenal glands** (ah-dre'nal): endocrine glands; one superior to each kidney; also called *suprarenal glands*.

**aerobic** (a-er-o'bik): requiring free O<sub>2</sub> for growth and metabolism as in the case of certain bacteria called *aerobes*.

**allantois** (ah-lan'to-is): an extraembryonic membranous sac that forms blood cells and gives rise to the fetal umbilical arteries and vein. It also contributes to the formation of the urinary bladder.

**alveolus** (al-ve'o-lus): an individual air capsule within the lung. Alveoli are the basic functional units of respiration. Also, the socket that secures a tooth.

**amnion** (am'ne-on): a membrane that surrounds the fetus to contain the amniotic fluid.

**amphiarthrosis** (am'fe-ar-thro'sis): a slightly moveable joint in a functional classification of joints.

**anatomical position** (an'ah-tom'e-kal): an erect body stance with the eyes directed forward, the arms at the sides, and the palms of the hands facing forward.

**anatomy** (ah-nat'o-me): the branch of science concerned with the structure of the body and the relationship of its organs.

**antebrachium** (an'te-bra'ke-um): the forearm.

**anterior (ventral)** (an-te're-or): toward the front; the opposite of *posterior (dorsal)*.

**antigen** (an'te-jen): a substance which causes cells to produce antibodies.

**anus** (a'nus): the terminal end of the GI tract, opening of the anal canal.

**aorta** (a-or'tah): the major systemic vessel of the arterial portion of the circulatory system, emerging from the left ventricle.

**apocrine gland** (ap'o-krin): a type of sweat gland that functions in evaporative cooling.

**appendix** (ah-pen'diks): a short pouch that attaches to the cecum.

**aqueous humor** (a'kwe-us hu'mor): the watery fluid that fills the anterior and posterior chambers of the eye.

**arachnoid mater** (ah-rak'noid ma'ter): the weblike middle covering (meninx) of the central nervous system.

**arbor vitae** (ar'bor vi'tah): the branching arrangement of white matter within the cerebellum.

**areola** (ah-re'o-lah): the pigmented ring around the nipple.

**artery** (ar'ter-e): a blood vessel that carries blood away from the heart.

**articular cartilage** (ar-tik'u-lar kar'ti-lij): a hyaline cartilaginous covering over the articulating surface of bones of synovial joints.

**ascending colon** (ko'lon): the portion of the large intestine between the cecum and the right colic (hepatic) flexure.

**atom** (at'om): the smallest unit of an element that can exist and still have the properties of the element; collectively, atoms form molecules in a compound.

**atrium** (a'tre-um): either of two superior chambers of the heart that receive venous blood.

**atrophy** (at'ro-fe): a wasting away or decrease in size of a cell or organ.

**auditory tube** (aw'di-to're): a narrow canal that connects the middle ear chamber to the pharynx; also called the *eustachian canal*.

**autonomic** (aw-to-nom'ik): self-governing; pertaining to the division of the nervous system which controls involuntary activities.

**axilla** (ak-sil'ah): the depressed hollow under the arm; the armpit.

**axon** (ak'son): The elongated process of a neuron (nerve cell) that transmits an impulse away from the cell body.

## B

**basement membrane**: a thin sheet of extracellular substance to which the basal surfaces of membranous epithelial cells are attached.





**basophil** (ba'so-fil): a granular leukocyte that readily stains with basophilic dye.

**belly**: the thickest circumference of a skeletal muscle.

**benign**: (be-nine'): nonmalignant; a confined tumor.

**blastula** (blas'tu-lah): an early stage of prenatal development between the morula and embryonic stages.

**blood**: the fluid connective tissue that circulates through the cardiovascular system to transport substances throughout the body.

**bolus** (bo'lus): a moistened mass of food that is swallowed from the oral cavity into the pharynx.

**bone**: an organ composed of solid, rigid connective tissue, forming a component of the skeletal system.

**Bowman's capsule** (bo'manz kap'sul): see *glomerular capsule*.

**brain**: the enlarged superior portion of the central nervous system, located in the cranial cavity of the skull.

**brain stem**: the portion of the brain consisting of the medulla oblongata, pons, and midbrain.

**bronchial tree** (brong'ke-al): the bronchi and their branching bronchioles.

**bronchiole** (brong'ke-ol): a small division of a bronchus within the lung.

**bronchus** (bron'kus): a branch of the trachea that leads to a lung.

**buccal cavity** (buk'al): the mouth, or oral cavity.

**bursa** (ber'sah): a saclike structure filled with synovial fluid, which occurs around joints.

**buttock** (but'ok): the rump or fleshy mass on the posterior aspect of the lower trunk, formed primarily by the gluteal muscles.

## C

**calorie** (kal'o-re): the unit of heat required to raise the temperature of one gram of water one degree centigrade.

**calyx** (ka'liks): a cup-shaped portion of the renal pelvis that encircles a renal papilla.

**cancellous bone** (kan'se-lus): spongy bone; bone tissue with a latticelike structure.

**capillary** (kap'i-lar'e): a microscopic blood vessel that connects an arteriole and a venule; the functional unit of the circulatory system.

**carcinogenic** (kar-si-no-jen'ik): stimulating or causing the growth of a malignant tumor, or cancer.

**carpus** (kar'pus): the proximal portion of the hand that contains the eight carpal bones.

**cartilage** (kar'ti'lij): a type of connective tissue with a solid elastic matrix.

**caudal** (kaw'dal): referring to a position more toward the tail.

**cecum** (se'kum): the pouchlike portion of the large intestine to which the ileum of the small intestine is attached.

**cell**: the structural and functional unit of an organism; the smallest structure capable of performing all the functions necessary for life.

**central nervous system (CNS)**: the brain and the spinal cord.

**centrosome** (sen'tro-som): a dense body near the nucleus of a cell that contains a pair of centrioles.

**cerebellum** (ser'e-bel'um): the portion of the brain concerned with the coordination of movements and equilibrium.

**cerebrospinal fluid** (ser'e-bro-spi'nal): a fluid that buoys and cushions the central nervous system.

**cerebrum** (ser'e-brum): the largest portion of the brain, composed of the right and left hemispheres.

**cervical** (ser'vi-kal): pertaining to the neck or a necklike portion of an organ.

**choanae** (ko-a'na): the two posterior openings from the nasal cavity into the nasopharynx.

**cholesterol** (ko-les'ter-ol): an organic fat-like compound found in animal fat, bile, blood, liver, and other parts of the body.

**chondrocyte** (kon'dro-site): a cartilage cell.

**chorion** (ko're-on): An extraembryonic membrane that participates in the formation of the placenta.

**choroid** (ko'roid): the vascular, pigmented middle layer of the wall of the eye.

**chromosome** (kro'mo-som): structure in the nucleus that contains the genes for genetic expression.

**chyme** (kime): The mass of partially digested food that passes from the stomach into the duodenum of the small intestine.

**cilia** (sil'e-ah): microscopic, hairlike processes that move in a wavelike manner on the exposed surfaces of certain epithelial cells.

**ciliary body** (sil'e-er'e): a portion of the choroid layer of the eye that secretes aqueous humor and contains the ciliary muscle.

**circumduction** (ser'kum-duk'shun): a conelike movement of a body part, such that the distal end moves in a circle while the proximal portion remains relatively stable.

**clitoris** (kli'to-ris): a small, erectile structure in the vulva of the female.

**cochlea** (kok'le-ah): the spiral portion of the inner ear that contains the spiral organ (organ of Corti).

**ceolom** (se'lom): the abdominal cavity.

**colon** (ko'lon): the first portion of the large intestine.

**common bile duct**: a tube that is formed by the union of the hepatic duct and cystic duct, transports bile to the duodenum.

**compact bone**: tightly packed bone that is superficial to spongy bone; also called *dense bone*.

**condyle** (kon'dile): a rounded process at the end of a long bone that forms an articulation.

**connective tissue**: one of the four basic tissue types within the body. It is a binding and supportive tissue with abundant matrix.



**cornea** (kor'ne-ah): the transparent convex, anterior portion of the outer layer of the eye.

**cortex** (kor'teks): the outer layer of an organ such as the convoluted cerebrum, adrenal gland, or kidney.

**costal cartilage** (kos'tal): the cartilage that connects the ribs to the sternum.

**cranial** (kra'ne-al): pertaining to the cranium.

**cranial nerve**: one of twelve pairs of nerves that arise from the inferior surface of the brain.

## D

**dentin** (den'tine): the principal substance of a tooth, covered by enamel over the crown and by cementum on the root.

**dermis** (der'mis): the second, or deep, layer of skin beneath the epidermis.

**descending colon**: the segment of the large intestine that descends on the left side from the level of the spleen to the level of the left iliac crest.

**diaphragm** (di'ah-fram): a flat dome of muscle and connective tissue that separates the thoracic and abdominal cavities.

**diaphysis** (di-af'i-sis): the shaft of a long bone.

**diastole** (di-as'to-le): the sequence of the cardiac cycle during which the ventricular heart chamber wall is relaxed.

**diarthrosis** (di'ar-thro'sis): a freely movable joint.

**distal** (dis'tal): away from the midline or origin; the opposite of *proximal*.

**dorsal** (dor'sal): pertaining to the back or posterior portion of a body part; the opposite of *ventral*.

**ductus deferens** (duk'tus def'er-enz): a tube that carries spermatozoa from the epididymis to the ejaculatory duct: also called the *vas deferens* or *seminal duct*.

**duodenum** (du'o-num): the first portion of the small intestine.

**dura mater** (du'rah ma'ter): the outermost meninx covering the central nervous system.

## E

**eccrine gland** (ek'rin): a sweat gland that functions in body cooling.

**ectoderm** (ek'to-derm): the outermost of the three primary embryonic germ layers.

**edema** (e-de'mah): an excessive retention of fluid in the body tissues.

**effector** (ef-fek'tor): an organ such as a gland or muscle that responds to motor stimulation.

**efferent** (ef'er-ent): conveying away from the center of an organ or structure.

**ejaculation** (e-jak'u-la'shun): the discharge of semen from the male urethra during climax.

**electrocardiogram** (e-lek'tro-kar'de-o-gram'): a recording of the electrical activity that accompanies the cardiac cycle; also called ECG or EKG.

**electroencephalogram** (e-lek'tro-en-sef'ah-lo-gram): a recording of the brain wave pattern; also called EEG.

**electromyogram** (e-lek'tro-mi'o-gram): a recording of the activity of a muscle during contraction: also called EMG.

**electrolyte** (e-lek'tro-lite): a solution that conducts electricity by means of charged ions.

**electron** (e-lek'tron): the unit of negative electricity.

**enamel** (en-am'el): the outer, dense substance covering the crown of a tooth.

**endocardium** (en'do-kar'de-um): the fibrous lining of the heart chambers and valves.

**endochondral bone** (en'do-kon'dral): bones that form as hyaline cartilage models first and then are ossified.

**endocrine gland** (en'do-krine): hormone producing gland that is part of the endocrine system.

**endoderm** (en'do-derm): the innermost of the three primary germ layers of an embryo.

**endometrium** (en'do-me'tre-um): the inner lining of the uterus.

**endothelium** (en'do-the'le-um): the layer of epithelial tissue that forms the thin inner lining of blood vessels.

**eosinophil** (e'o-sin'o-fil): a type of white blood cell that becomes stained by acidic eosin dye; constitutes about 2%–4% of the white blood cells.

**epicardium** (ep'i-kar'de-um): the thin, outer layer of the heart: also called the *visceral pericardium*.

**epidermis** (ep'i-der'mis): the outermost layer of the skin, composed of stratified squamous epithelium.

**epididymis** (ep'i-did'i-mis): a coiled tube located along the posterior border of the testis; stores spermatozoa and discharges them during ejaculation.

**epidural space** (ep'i-du'ral): a space between the spinal dura mater and the bone of the vertebral canal.

**epiglottis** (ep'i-glot'is): a leaflike structure positioned on top of the larynx that covers the glottis during swallowing.

**epinephrine** (ep'i-nef'rin): a hormone secreted from the adrenal medulla resulting in action similar to those from sympathetic nervous system stimulation; also called *adrenaline*.

**epiphyseal plate** (ep'i-fize-al): a cartilaginous layer located between the epiphysis and diaphysis of a long bone and functions in longitudinal bone growth.

**epiphysis** (e-pif'i-sis): the end segment of a long bone, distinct in early life but later becoming part of the larger bone.

**epithelial tissue** (ep'i-the'le-al): one of the four basic tissue types; the type of tissue that covers or lines all exposed body surfaces.

**erythrocyte** (e-rith'ro-site): a red blood cell.



**esophagus** (e-sof'ah-gus): a tubular organ of the GI tract that leads from the pharynx to the stomach.

**estrogen** (es'tro-jen): female sex hormone secreted from the ovarian (Graafian) follicle.

**eustachian canal** (u-sta'ke-an): see *auditory tube*.

**excretion** (eks-kre'shun): discharging waste material.

**exocrine gland** (ek'so-krin): a gland that secretes its product to an epithelial surface, directly or through ducts.

**expiration** (ek'spi-ra'shun): the process of expelling air from the lungs through breathing out; also called *exhalation*.

**extension** (ek-sten'shun): a movement that increases the angle between two bones of a joint; opposite of flexion.

**external ear**: the outer portion of the ear, consisting of the auricle (pinna), and external auditory canal.

**extracellular** (esk-trah-sel'u-lar): outside a cell or cells.

**extrinsic** (eks-trin'sik): pertaining to an outside or external origin.

## F

**facet** (fas'et): a small, smooth surface of a bone where articulation occurs.

**fallopian tube** (fal-lo'pe-an): see *uterine tube*.

**fascia** (fash'e-ah): a tough sheet of fibrous connective tissue binding the skin to underlying muscles or supporting and separating muscle.

**fasciculus** (fah-sik'u-lus): a bundle of muscle or nerve fibers.

**feces** (fe'sez): waste material expelled from the GI tract during defecation, composed of food residue, bacteria, and secretions; also called *stool*.

**fetus** (fe'tus): the unborn offspring during the last stage of prenatal development.

**filtration** (fil-tra'shun): the passage of a liquid through a filter or a membrane.

**fimbriae** (fim'bre-e): fringelike extensions from the borders of the open end of the uterine tube.

**fissure** (fish'ure): a groove or narrow cleft that separates two parts of an organ.

**flexion** (flek'shun): a movement that decreases the angle between two bones of a joint; opposite of extension.

**fontanel** (fon'tah-nel): a membranous-covered region on the skull of a fetus or baby where ossification has not yet occurred; also called a *soft spot*.

**foot**: the terminal portion of the lower extremity, consisting of the tarsus, metatarsus, and digits.

**foramen** (fo-ra'men): an opening in an anatomical structure for the passage of a blood vessel or a nerve.

**foramen ovale** (o-val'e): the opening through the interatrial septum of the fetal heart.

**fossa** (fos'ah): a depressed area, usually on a bone.

**fourth ventricle** (ven'tri-k'l): a cavity within the brain containing cerebrospinal fluid.

**fovea centralis** (fo've-ah sen'tra'lis): a depression on the macula lutea of the eye where only cones are located, which is the area of keenest vision.

## G

**gallbladder**: a pouchlike organ, attached to the inferior side of the liver, which stores and concentrates bile.

**gamete** (gam'ete): a haploid sex cell, sperm or egg.

**gamma globulins** (gam'mah glob'u-lins): protein substances often found in immune serums that act as antibodies.

**ganglion** (gang'gle-on): an aggregation of nerve cell bodies outside the central nervous system.

**gastrointestinal tract** (gas'tro-in-tes'tin-al): the tubular portion of the digestive system that includes the stomach and the small and large intestines; also called the *GI tract*.

**gene** (jene): one of the biologic units of heredity; parts of the DNA molecule located in a definite position on a certain chromosome.

**genetics** (je-net'iks): the study of heredity.

**gingiva** (jin-ji'vah): the fleshy covering over the mandible and maxilla through which the teeth protrude within the mouth; also called the *gum*.

**gland**: an organ that produces a specific substance or secretion.

**glans penis** (glanz pe'nis): the enlarged, distal end of the penis.

**glomerular capsule** (glo-mer'u-lar): the double-walled proximal portion of a renal tubule that encloses the glomerulus of a *nephron*; also called *Bowman's capsule*.

**glomerulus** (glo-mer'u-lus): a coiled tuft of capillaries that is surrounded by the glomerular capsule and filters urine from the blood.

**glottis** (glot'is): a slitlike opening into the larynx, positioned between the vocal folds.

**glycogen** (gli'ko-jen): the principal storage carbohydrate in animals. It is stored primarily in the liver and is made available as glucose when needed by the body cells.

**goblet cell**: a unicellular gland within columnar epithelia that secretes mucus.

**gonad** (go'nad): a reproductive organ, testis or ovary, that produces gametes and sex hormones.

**gray matter**: the portion of the central nervous system that is composed of nonmyelinated nervous tissue.

**greater omentum** (o-men'tum): a double-layered peritoneal membrane that originates on the greater curvature of the stomach and extends over the abdominal viscera.

**gut**: pertaining to the intestine; generally a developmental term.

**gyrus** (ji'rus): a convoluted elevation or ridge.





## H

**hair:** an epidermal structure consisting of keratinized dead cells that have been pushed up from a dividing basal layer.

**hair cells:** specialized receptor nerve endings for responding to sensations, such as in the spiral organ of the inner ear.

**hair follicle** (fol'li-k'l): a tubular depression in the skin in which a hair develops.

**hand:** the terminal portion of the upper extremity, consisting of the carpus, metacarpus, and digits.

**hard palate** (pal'at): the bony partition between the oral and nasal cavities, formed by the maxillae and palatine bones.

**haustra** (haws'trh): sacculations or pouches of the colon.

**haversian system** (ha-ver'shan): see *osteon*.

**heart:** a muscular, pumping organ positioned in the thoracic cavity.

**hematocrit** (he-mat'o-krit): the volume percentage of red blood cells in whole blood.

**hemoglobin** (he'mo-glo'bin): the pigment of red blood cells that transports O<sub>2</sub> and CO<sub>2</sub>.

**hemopoiesis** (hem'ah-poi-e'sis): production of red blood cells.

**hepatic portal circulation** (por'tal): the return of venous blood from the digestive organs and spleen through a capillary network within the liver before draining into the heart.

**heredity** (he-red'i-te): the transmission of certain characteristics, or traits, from parents to offspring, via the genes.

**hiatus** (hi-a'tus): an opening or fissure.

**hilum** (hi'lum): a concave or depressed area where vessels or nerves enter or exit an organ.

**histology** (his-tol'o-je): microscopic anatomy of the structure and function of tissues.

**homeostasis** (ho-me-o-sta'sis): a consistency and uniformity of the internal body environment which maintains normal body function.

**hormone** (hor'mone): a chemical substance that is produced in an endocrine gland and secreted into the bloodstream to cause an effect in a specific target organ.

**hyaline cartilage** (hi'ah-line): the most common kind of cartilage in the body, occurring at the articular ends of bones, in the trachea, and within the nose, and forms the precursor to most of the bones of the skeleton.

**hymen** (hi'men): a developmental remnant (vestige) of membranous tissue that partially covers the vaginal opening.

**hyperextension** (hi'per-ek-sten'shun): extension beyond the normal anatomical position of 180°.

**hypothalamus** (hi'po-thal'ah-mus): a structure within the brain below the thalamus, which functions as an autonomic center and regulates the pituitary gland.

## I

**ileocecal valve** (il'e-o-se'kal): a specialization of the mucosa at the junction of the small and large intestine that forms a one-way passage and prevents the backflow of food materials.

**ileum** (il'e-um): the terminal portion of the small intestine between the jejunum and cecum.

**inferior vena cava** (ve'nah ka'vah): a systemic vein that collects blood from the body regions inferior to the level of the heart and returns it to the right atrium.

**inguinal** (ing'gwi-nal): pertaining to the groin region.

**inguinal canal:** the passage in the abdominal wall through which a testis descends into the scrotum.

**insertion:** the more moveable attachment of a muscle, usually more distal in location.

**inspiration** (in'spi-ra'shun): the act of breathing air into the alveoli of the lungs; also called *inhalation*.

**integument** (in-teg'u-ment): pertaining to the skin.

**internal ear:** the innermost portion or chamber of the ear, containing the cochlea and the vestibular organs.

**interstitial** (in-ter-stish'al): pertaining to spaces or structures between the functioning active tissue of any organ.

**intracellular** (in-trah-sel'u-lar): within the cell itself.

**intervertebral disc** (in'ter-ver'te-bral): a pad of fibrocartilage between the bodies of adjacent vertebrae.

**intestinal gland** (in-tes'ti-nal): a simple tubular digestive gland that opens onto the surface of the intestinal mucosa and secretes digestive enzymes; also called *crypt of Lieberkuhn*.

**intrinsic** (in-trin'sik): situated in or pertaining to an internal organ.

**iris** (i'ris): the pigmented, vascular tunic portion of the eye that surrounds the pupil and regulates its diameter.

**islets of Langerhans** (i'lets of lahng'er-hanz): see *pancreatic islets*.

**isotope** (i'so-tope): a chemical element that has the same atomic number as another but a different atomic weight.

**isthmus** (is'mus): a narrow neck or portion of tissue connecting two structures.

## J

**jejunum** (je-joo'num): the middle portion of the small intestine, located between the duodenum and the ileum.

**joint capsule** (kap'sule): the fibrous tissue that encloses the joint cavity of a synovial joint.

**jugular** (jug'u-lar): pertaining to the veins of the neck which drain the areas supplied by the carotid arteries.

**K**

**karyotype** (kar'e-o-tip): the arrangement of chromosomes that is characteristic of the species or of a certain individual.

**keratin** (ker'ah-tin): an insoluble protein present in the epidermis and in epidermal derivatives such as hair and nails.

**kidney** (kid'ne): one of the paired organs of the urinary system that contains nephrons and filters wastes from the blood in the formation of urine.

**L**

**labia majora** (la'be-ah ma-jor'ah): a portion of the external genitalia of a female, consisting of two longitudinal folds of skin extending downward and backward from the mons pubis.

**labia minora** (ma-nor'ah): two small folds of skin, devoid of hair and sweat glands, lying between the labia majora of the external genitalia of a female.

**lacrimal gland** (lak'ri-mal): a tear-secreting gland, located on the superior lateral portion of the eyeball underneath the upper eyelid.

**lactation** (lak-ta'shun): the production and secretion of milk by the mammary glands.

**lacteal** (lak'te-al): a small lymphatic duct within a villus of the small intestine.

**lacuna** (lah-ku'nah): a hollow chamber that houses an osteocyte in mature bone tissue or a chondrocyte in cartilage tissue.

**lamella** (lah-mel'ah): a concentric ring of matrix surrounding the central canal in an osteon of mature bone tissue.

**large intestine**: the last major portion of the GI tract, consisting of the cecum, colon, rectum, and anal canal.

**larynx** (lar'inks): the structure located between the pharynx and trachea that houses the vocal folds (cords); commonly called the *voice box*.

**lens** (lenz): a transparent refractive structure of the eye, derived from ectoderm and positioned posterior to the pupil and iris.

**leukocyte** (lu'ko-site): a white blood cell; also spelled *leucocyte*.

**ligament** (lig'ah-ment): a fibrous band or cord of connective tissue that binds bone to bone to strengthen and provide support to the joint; also may support viscera.

**limbic system** (lim'bik): a portion of the brain concerned with emotions and autonomic activity.

**linea alba** (lin'e-ah al'bah): a fibrous band extending down the anterior medial portion of the abdominal wall.

**locus** (lo'kus): the specific location or site of a gene within the chromosome.

**lumbar** (lum'bar): pertaining to the region of the loins.

**lumen** (lu'men): the space within a tubular structure through which a substance passes.

**lung**: one of the two major organs of respiration within the thoracic cavity.

**lymph** (limf): a clear fluid that flows through lymphatic vessels.

**lymph node**: a small, ovoid mass located along the course of lymph vessels.

**lymphocyte** (lim'fo-site): a type of white blood cell.

**M**

**macula lutea** (mak'u-lah lu'te-ah): a depression in the retina that contains the fovea centralis, the area of keenest vision.

**malignant** (mah-lig'nant): a disorder that becomes worse and eventually causes death, as in cancer.

**malnutrition** (mal-nu-trish'un): any abnormal assimilation of food; receiving insufficient nutrients.

**mammary gland** (mam'er-e): the gland of the female breast responsible for lactation and nourishment of the young.

**marrow** (mar'o): the soft vascular tissue that occupies the inner cavity of certain bones and produces blood cells.

**matrix** (ma'triks): the intercellular substance of a tissue.

**meatus** (me-a'tus): an opening or passageway into a structure.

**mediastinum** (me'de-as-ti-num): the partition in the center of the thorax between the two pleural cavities.

**medulla** (me-dul'ah): the center portion of an organ.

**medulla oblongata** (ob'long-ga'tah): a portion of the brain stem between the pons and the spinal cord.

**medullary cavity** (med'u-lar'e): the hollow center of the diaphysis of a long bone, occupied by marrow.

**meiosis** (mi-o'sis): cell division by which gametes, or haploid sex cells, are formed.

**melanocyte** (mel'ah-no-site): a pigment-producing cell in the deepest epidermal layer of the skin.

**membranous bone** (mem'brah-nus): bone that forms from membranous connective tissue rather than from cartilage.

**menarche** (me-nar'ke): the first menstrual discharge.

**meninges** (me-nin'jez): a group of three fibrous membranes that cover the central nervous system.

**menisci** (men-is'si): wedge-shaped cartilages in certain synovial joints.

**menopause** (men'o-pawz): the cessation of menstrual periods in the human female.

**menses** (men'sez): the monthly flow of blood from the female genital tract.

**menstrual cycle** (men'stru-al): the rhythmic female reproductive cycle, characterized by changes in hormone levels and physical changes in the uterine lining.

**menstruation** (men'stru-a'shun): the discharge of blood and tissue from the uterus at the end of the menstrual cycle.

**mesentery** (mes'en-ter'e): a fold of peritoneal membrane that attaches an abdominal organ to the abdominal wall.

**mesoderm** (mes'o-derm): the middle one of the three primary germ layers.



**mesothelium** (mes'ō-the'leum): a simple squamous epithelial tissue that lines body cavities and covers visceral organs; also called *serosa*.

**metabolism** (me-tab'ō-lizm): the chemical changes that occur within a cell.

**metacarpus** (met'ah-kar'pus): the region of the hand between the wrist and the digits, including the five bones that support the palm of the hand.

**metastasis** (me-tas'tah-sis): the spread of a disease from one organ or body part to another.

**metatarsus** (met'ah-tar'sus): the region of the foot between the ankle and the digits, containing five bones.

**microbiology** (mi-kro-bi-ol'o-je): the science dealing with microscopic organisms, including bacteria, fungi, viruses, and protozoa.

**microvilli** (mi'kro-vil'i): microscopic, invaginations of cell membranes on certain epithelial cells.

**midbrain**: the portion of the brain between the pons and the forebrain.

**middle ear**: the middle of the three ear chambers, containing the three auditory ossicles.

**mitosis** (mi-to'sis): the process of cell division, in which the two daughter cells are identical and contain the same number of chromosomes.

**mitral valve** (mi'tral): the left atrioventricular heart valve; also called the bicuspid valve.

**mixed nerve**: a nerve containing both motor and sensory nerve fibers.

**molecule** (mol'e-kule): a minute mass of matter, composed of a combination of atoms that form a given chemical substance or compound.

**motor neuron** (nu'ron): a nerve cell that conducts action potential away from the central nervous system and innervates effector organs (muscles and glands); also called *efferent neuron*.

**motor unit**: a single motor neuron and the muscle fibers it innervates.

**mucosa** (mu-ko'sah): a mucous membrane that lines cavities and tracts opening to the exterior.

**muscle** (mus'el): an organ adapted to contract; three types of muscle tissue are cardiac, smooth, and skeletal.

**mutation** (mu-ta'shun): a variation in an inheritable characteristic, a permanent transmissible change in which the offspring differ from the parents.

**myelin** (mi'e-lin): a lipoprotein material that forms a sheathlike covering around nerve fibers.

**myocardium** (mi'o-kar'de-um): the cardiac muscle layer of the heart.

**myofibril** (mi'o-fi'bril): a bundle of contractile fibers within muscle cells.

**myoneural junction** (mi'o-nu'ral): the site of contact between an axon of a motor neuron and a muscle fiber.

**myosin** (mi'o-sin): a thick filament protein that together with actin causes muscle contraction.

## N

**nail**: a hardened, keratinized plate that develops from the epidermis and forms a protective covering on the dorsal surfaces of the digits.

**nares** (na'rez): the opening into the nasal cavity; also called *nostrils*.

**nasal cavity** (na'zal): a mucosa-lined space above the oral cavity, which is divided by a nasal septum and is the first chamber of the respiratory system.

**nasal septum** (sep'tum): a bony and cartilaginous partition that separates the nasal cavity into two portions.

**nephron** (nef'ron): the functional unit of the kidney, consisting of a glomerulus, glomerular capsule, convoluted tubules, and the loop of the nephron.

**nerve**: a bundle of nerve fibers outside the central nervous system.

**neurofibril node** (nu'ro-fi'bril): a gap in the myelin sheath of a nerve fiber; also called the *node of Ranvier*.

**neuroglia** (nu-rog'le-ah): specialized supportive cells of the central nervous system.

**neurolemmocyte** (nu'ri-lem-o'site): a specialized neuroglia cell that surrounds an axon fiber of a peripheral neuron and forms the neurilemmal sheath; also called the *Schwann cell*.

**neuron** (nu'ron): the structural and functional unit of the nervous system, composed of a cell body, dendrites, and an axon; also called a *nerve cell*.

**neutrophil** (nu'tro-fil): a type of phagocytic white blood cell.

**nipple**: a dark pigmented, rounded projection at the tip of the breast.

**node of Ranvier** (rah-ve-a'): see *neurofibril node*.

**notochord** (no'to-kord): a flexible rod of tissue that extends the length of the back of an embryo.

**nucleus** (nu'kle-us): a spheroid body within a cell that contains the genetic factors of the cell.

**nurse cells**: specialized cells within the testes that supply nutrients to developing spermatozoa; also called *Sertoli cells* or *sustentacular cells*.

## O

**olfactory** (ol-fak'to-re): pertaining to the sense of smell.

**oocyte** (o'o-site): a developing egg cell.

**oogenesis** (o'o-hen'e-sis): the process of female gamete formation.

**optic** (op'tik): pertaining to the eye and the sense of vision.

**optic chiasma** (ki-as'mah): an X-shaped structure on the inferior aspect of the brain where there is a partial crossing over of fibers in the optic nerves.





**optic disc:** a small region of the retina where the fibers of the ganglion neurons exit from the eyeball to form the optic nerve; also called the *blind spot*.

**oral:** pertaining to the mouth; also called *buccal*.

**organ:** a structure consisting of two or more tissues, which performs a specific function.

**organelle** (or'gan-el'): a minute structure of a cell with a specific function.

**organism** (or'gah-nizm): an individual living creature.

**orifice** (or'i fis): an opening into a body cavity or tube.

**origin** (or'i-jin): the place of muscle attachment onto the more stationary point or proximal bone; opposite the insertion.

**osmosis** (os-mo'sis): the passage of a solvent, such as water, from a solution of lesser concentration to one of greater concentration through a semipermeable membrane.

**ossicle** (os'si-kel): one of the three bones of the middle ear.

**osteocyte** (os'te-o-site): a mature bone cell.

**osteon** (os'te-on): a group of osteocytes and concentric lamellae surrounding a central canal within bone tissue; also called a *Haversian system*.

**ovarian follicle** (o-va're-an fol'li-k'l): a developing ovum and its surrounding epithelial cells.

**ovary** (o'vah-re): the female gonad in which ova and certain sexual hormones are produced.

**oviduct** (o'vi-dukt): the tube that transports ova from the ovary to the uterus; also called the *uterine tube* or *fallopian tube*.

**ovulation** (o'vu-la'shun): the rupture of an ovarian follicle with the release of an ovum.

**ovum** (o'vum): a secondary oocyte after ovulation but before fertilization.

## P

**palate** (pal'at): the roof of the oral cavity.

**palmar** (pal'mar): pertaining to the palm of the hand.

**pancreas** (pah'kre-as): organ in the abdominal cavity that secretes gastric juices into the GI tract and insulin and glucagon into the blood.

**pancreatic islets** (pan'kre-at'ik): a cluster of cells within the pancreas that forms the endocrine portion of the pancreas; also called *islets of Langerhans*.

**papillae** (pah-pil'e): small fingerlike projections.

**paranasal sinus** (par'ah-na'zal si'nus): an air chamber lined with a mucous membrane that communicates with the nasal cavity.

**parasympathetic** (par'ah-smi'pah-thet'ik): pertaining to the division of the autonomic nervous system concerned with activities that are antagonistic to sympathetic.

**parathyroids** (par'ah-thi'roids): small endocrine glands that are embedded on the posterior surface of the thyroid glands and are concerned with calcium metabolism.

**parietal** (pah-ri'e-tal): pertaining to a wall of an organ or cavity.

**parotid gland:** (pah-rot'id): one of the paired salivary glands on the side of the face over the masseter muscle.

**parturition** (par'tu-rish'un): the process of childbirth.

**pathogen** (path'o-jen): any disease-producing organism.

**pectoral girdle** (pek'to-ral): the portion of the skeleton that supports the upper extremities.

**pelvic** (pel'vik): pertaining to the pelvis.

**pelvic girdle:** the portion of the skeleton to which the lower extremities are attached.

**penis** (pe'nis): the external male genital organ, through which urine passes during urination and which transports semen to the female during coitus.

**pericardium** (per'i-kar'de-um): a protective serous membrane that surrounds the heart.

**perineum** (per'i-ne'um): the floor of the pelvis, which is the region between the anus and the scrotum in the male and between the anus and the vulva in the female.

**periosteum** (per'e-os'te-um): a fibrous connective tissue covering the outer surface of bone.

**peripheral nervous system** (pe-rif'er-al): the nerves and ganglia of the nervous system that lie outside of the brain and spinal cord.

**peristalsis** (per'i-stal'sis): rhythmic contractions of smooth muscle in the walls of various tubular organs, which move the contents along.

**peritoneum** (per'i-to-ne'um): the serous membrane that lines the abdominal cavity and covers the abdominal viscera.

**phagocyte** (fag'o-site): any cell that engulfs other cells, including bacteria, or small foreign particles.

**phalanx** (fa'lanks), pl. *phalanges*: a bone of the finger or toe.

**pharynx** (far'inks): the organ of the GI tract and respiratory system located at the back of the oral and nasal cavities and extending to the larynx anteriorly and the esophagus posteriorly; also called the *throat*.

**physiology** (fiz'e-ol'o-je): the science that deals with the study of body functions.

**pia mater** (pi'ah ma'ter): the innermost meninx that is in direct contact with the brain and spinal cord.

**pineal gland** (pin'e-al): a small cone-shaped gland located in the roof of the third ventricle.

**pituitary gland** (pi-tu'i-tar'e): a small, pea-shaped endocrine gland situated on the inferior surface of the brain that secretes a number of hormones; also called the *hypophysis* and commonly called the "*master gland*."

**placenta** (plah-sen'tah): the organ of metabolic exchange between the mother and the fetus.

**plasma** (plaz'mah): the fluid, extracellular portion of circulating blood.

**platelets** (plate'lets): fragments of specific bone marrow cells that function in blood coagulation; also called *thrombocytes*.

**pleural membranes** (ploor'al): serous membranes that surround the lungs and line the thoracic cavity.



**plexus** (plek'sus): a network of interlaced nerves or vessels.

**plica circulares** (pli'kah ser-ku-lar'is): a circular deep fold within the wall of the small intestine that increases the absorptive surface area.

**pons** (ponz): the portion of the brain stem just above the medulla oblongata and anterior to the cerebellum.

**posterior (dorsal)** (pos-ter'e-or): toward the back.

**pregnancy**: a condition where a female has a developing offspring in the uterus.

**prenatal** (pre-na'tal): the period of offspring development during pregnancy; before birth.

**proprioceptor** (pro'pre-o-sep'tor): a sensory nerve ending that responds to changes in tension in a muscle or tendon.

**prostate** (pros'tate): a walnut-shaped gland surrounding the male urethra just below the urinary bladder that secretes an additive to seminal fluid during ejaculation.

**proximal** (prok'si-mal): closer to the midline of the body or origin of an appendage: opposite of *distal*.

**puberty** (pu'ber-te): the period of development in which the reproductive organs become functional.

**pulmonary** (pul'mo-ner'e): pertaining to the lungs.

**pupil**: the opening through the iris that permits light to enter the vitreous chamber of the eyeball and be refracted by the lens.

## R

**receptor** (re-sep'tor): a sense organ or a specialized end of a sensory neuron that receives stimuli from the environment.

**rectum** (rek'tum): the portion of the GI tract between the sigmoid colon and the anal canal.

**reflex arc**: the basic conduction pathway through the nervous system, consisting of a sensory neuron, interneuron, and a motor neuron.

**renal** (re'nal): pertaining to the kidney.

**renal corpuscle** (kor'pus'l): the portion of the nephron consisting of the glomerulus and a glomerular capsule.

**renal pelvis**: the inner cavity of the kidney formed by the expanded ureter and into which the calyces open.

**replication** (re-ply-ka'shun): the process of producing a duplicate; a copying or duplication, such as DNA replication.

**respiration**: (res'pi-ra'shun): the exchange of gases between the external environment and the cells of an organism.

**rete testis** (re'te tes'tis): a network of ducts in the center of the testis, site of spermatozoa transport.

**retina** (ret'i-nah): the inner layer of the eye that contains the rods and cones.

**retraction** (re-trak'shun): the movement of a body part, such as the mandible, backward on a plane parallel with the ground; the opposite of *protraction*.

**rod**: a photoreceptor in the retina of the eye that is specialized for colorless, dim light vision.

**rotation** (ro-ta'shun): the movement of a bone around its own longitudinal axis.

**rugae** (ru'je): the folds or ridges of the mucosa of an organ.

## S

**sagittal** (saj'i-tal): a vertical plane through the body that divides it into right and left portions.

**salivary gland** (sal'i-ver-e): an accessory digestive gland that secretes saliva into the oral cavity.

**sarcolemma** (sar'ko-lem'ah): the cell membrane of a muscle fiber.

**sarcomere** (sar'ko-mere): the portion of a skeletal muscle fiber between the two adjacent Z lines that is considered the functional unit of a myofibril.

**Schwann cell** (shwahn): see *neurolemmocyte*.

**sclera** (skle'rah): the outer white layer of connective tissue that forms the protective covering of the eye.

**scrotum** (skro'tum): a pouch of skin that contains the testes and their accessory organs.

**sebaceous gland** (se-ba'shus): an exocrine gland of the skin that secretes *sebum*, an oily protective product.

**semen** (se'men): the secretion of the reproductive organs of the male, consisting of spermatozoa and additives.

**semicircular ducts**: tubular channels within the inner ear that contain the receptors for equilibrium; also called *semicircular canals*.

**semilunar valve** (sem'e-lu'nar): crescent-shaped heart valves, positioned at the entrances to the aorta and the pulmonary trunk.

**seminal vesicles** (sem'i-nal ves'i-k'lz): a pair of accessory male reproductive organs lying posterior and inferior to the urinary bladder, which secrete additives to spermatozoa into the ejaculatory ducts.

**sensory neuron** (nu'ron): a nerve cell that conducts an impulse from a receptor organ to the central nervous system; also called *afferent neuron*.

**serous membrane** (se'rus): an epithelial and connective tissue membrane that lines body cavities and covers viscera; also called *serosa*.

**sesamoid bone** (ses'ah-moid): a membranous bone formed in a tendon in response to joint stress.

**sigmoid colon** (sig'moid ko'lon): the S-shaped portion of the large intestine between the descending colon and the rectum.

**sinoatrial node** (sin'o-a'tre-al): a mass of specialized cardiac tissue in the wall of the right atrium that initiates the cardiac cycle; the SA node; also called the *pacemaker*.



**sinus** (si'nus): a cavity or hollow space within a body organ such as a bone.

**skeletal muscle**: a type of muscle tissue that is multinucleated, occurs in bundles, has crossbands of proteins, and contracts either in a voluntary or involuntary fashion.

**small intestine**: the portion of the GI tract between the stomach and the cecum, functions in absorption of food nutrients.

**smooth muscle**: a type of muscle tissue that is nonstriated, composed of fusiform, single-nucleated fibers, and contracts in an involuntary, rhythmic fashion within the walls of visceral organs.

**somatic** (so-mat'ik): pertaining to the nonvisceral parts of the body.

**spermatic cord** (sper'mat'ik): the structure of the male reproductive system composed of the ductus deferens, spermatic vessels, nerve, cremasteric muscle, and connective tissue.

**spermatogenesis** (sper'mah-to-jen'e-sis): the production of male sex gametes, or spermatozoa.

**spermatozon** (sper'mah-to-zo'on): a sperm cell, or gamete.

**sphincter** (sfingk'ter): a circular muscle that constricts a body opening or the lumen of a tubular structure.

**spinal cord** (spi'nal): the portion of the central nervous system that extends from the brain stem through the vertebral canal.

**spinal nerve**: one of the thirty-one pairs of nerves that arise from the spinal cord.

**spleen**: a large, blood-filled organ located in the upper left of the abdomen and attached by the mesenteries to the stomach.

**spongy bone** (spun'je): a type of bone that contains many porous spaces; also called *cancellous bone*.

**stomach**: a pouchlike digestive organ between the esophagus and the duodenum.

**submucosa** (sub'mu-ko'sah): a layer of supportive connective tissue that underlies a mucous membrane.

**superior vena cava** (ve'nah ka'vah): a large systemic vein that collects blood from regions of the body superior to the heart and returns it to the right atrium.

**surfactant** (ser-fak'tant): a substance produced by the lungs that decreases the surface tension within the alveoli.

**suture** (su'chur): a type of fibrous joint articulating between bones of the skull.

**sympathetic** (sim'pah-thet'ik): pertaining to that part of the autonomic nervous system concerned with activities antagonistic to the parasympathetic.

**synapse** (sin'aps): a minute space between the axon terminal of a presynaptic neuron and a dendrite of a postsynaptic neuron.

**synovial cavity** (si-no've-al): a space between the two bones of a synovial joint, filled with synovial fluid.

**system**: a group of body organs that function together.

**systole** (sis'to-le): the muscular contraction of the ventricles of the heart during the cardiac cycle.

**systolic pressure** (sis'tol'ik): arterial blood pressure during the ventricular systolic phase of the cardiac cycle.

## T

**target organ**: the specific body organ that a particular hormone affects.

**tarsus** (tahr'sus): pertaining to the ankle; the proximal portion of the foot that contains the seven tarsal bones.

**tendo calcaneus** (ten'do kal-ka'ne-us): the tendon that attaches the calf muscles to the calcaneus bone.

**tendon** (ten'dun): a band of dense regular connective tissue that attaches muscle to bone.

**testis** (tes'tis): the primary reproductive organ of a male, which produces spermatozoa and male sex hormones.

**thoracic** (tho-ras'ik): pertaining to the chest region.

**thoracic duct**: the major lymphatic vessel of the body, which drains lymph from the entire body except the upper right quadrant and returns it to the left subclavian vein.

**thorax** (tho'raks): the chest.

**thymus gland** (thi'mus): a bi-lobed lymphoid organ positioned in the upper mediastinum, posterior to the sternum and between the lungs.

**tissue**: an aggregation of similar cells and their binding intercellular substance, joined to perform a specific function.

**tongue**: a protrusible muscular organ on the floor of the oral cavity.

**trachea** (tra'ke-ah): the airway leading from the larynx to the bronchi; also called the *windpipe*.

**tract**: a bundle of nerve fibers within the central nervous system.

**transverse colon** (ko'lon): a portion of the large intestine that extends from right to left across the abdomen between the hepatic and splenic flexures.

**tricuspid valve** (tri-kus'pid): the heart valve between the right atrium and the right ventricle.

**tympenic membrane** (tim-pan'ik): the membranous eardrum positioned between the outer and middle ear; also called the *tympenum*, or the *ear drum*.

## U

**umbilical cord** (um-bil'i-kal): a cordlike structure containing the umbilical arteries and vein, which connects the fetus with the placenta.

**umbilicus** (um-bil'i-kus): the site where the umbilical cord was attached to the fetus: also called the *navel*.

**ureter** (u-re'ter): a tube that transports urine from the kidney to the urinary bladder.

**urethra** (u-re'thrah): a tube that transports urine from the urinary bladder to the outside of the body.

**urinary bladder** (u're-ner'e): a distensible sac in the pelvic cavity which stores urine.

**uterine tube** (u'ter-in): the tube through which the ovum is transported to the uterus and where fertilization takes place: also called the *oviduct* or *fallopian tube*.



**uterus** (u'ter-us): a hollow, muscular organ in which a fetus develops. It is located within the female pelvis between the urinary bladder and the rectum.

**uvula** (u'vu-lah): a fleshy, pendulous portion of the soft palate that blocks the nasopharynx during swallowing.

## V

**vagina** (vah-ji'nah): a tubular organ that leads from the uterus to the vestibule of the female reproductive tract and receives the male penis during coitus.

**vein**: a blood vessel that conveys blood toward the heart.

**ventral** (ven'tral): toward the front surface of the body: also called *anterior*.

**vestibular folds**: the supporting folds of tissue for the vocal folds within the larynx.

**vestibular window**: a membrane-covered opening in the bony wall between the middle and inner ear, into which the footplate of the stapes fits; also called *oval window*.

**viscera** (vis'er-ah): the organs within the abdominal or thoracic cavities.

**vitreous humor** (vit're-us hu'mor): the transparent gel that occupies the space between the lens and retina of the eye.

**vocal folds**: folds of the mucous membrane in the larynx that produce sound as they are pulled taut and vibrated; also called *vocal cords*.

**vulva** (vul'vah): the external genitalia of the female that surround the opening of the vagina; also called the *pudendum*.

## Z

**zygote** (zi'gote): a fertilized egg cell formed by the union of a sperm and an ovum.

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